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GUIDANCE FOR CONDUCTING REMEDIAL INVESTIGATIONS AND FEASIBILITY STUDIES UNDER CERCLA. (INTERIM REPT. (FINAL).)

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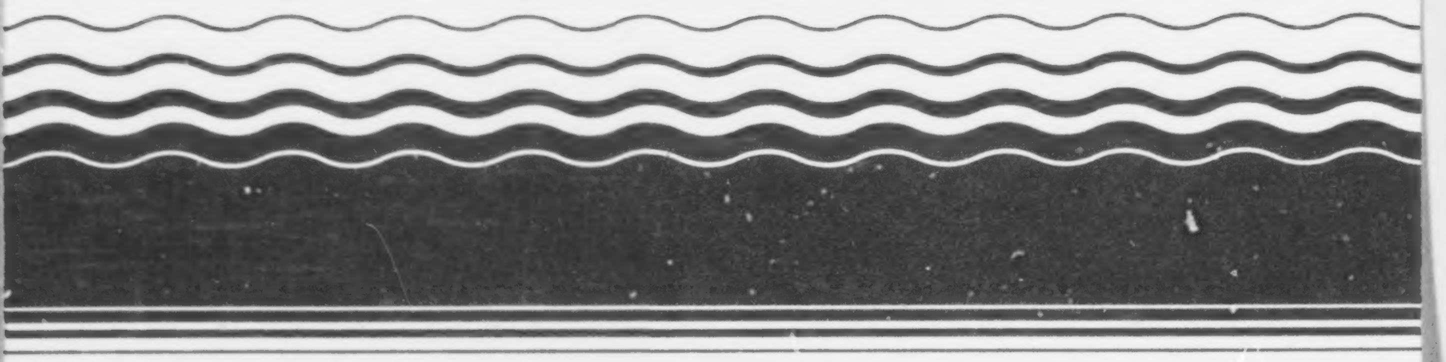

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U.S. Environmental Protection Agency
Washington, D.C. 20460

Notice

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Glossary

ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry: A branch of the Centers for Disease Control that is responsible for preparing health assessments at sites.
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, also known as Superfund: Amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA).
CLP	Contract Laboratory Program
CRL	Central regional laboratory
CRP	Community relations plan
CWA	Clean Water Act
DQO	Data quality objectives: Statements that specify the data needed to support decisions regarding remedial response activities.
EMSL-LV	Environmental Monitoring Systems Laboratory, Las Vegas
EPIC	Environmental Photographic Interpretation Center
ERA	Expedited response action
ESI	Expanded site investigation
FIT	Field investigation team
FS	Feasibility study
FSP	Field sampling plan: Defines in detail the sampling and data gathering activities to be used at a site. (See SAP.)
HSP	Health and safety plan
IRIS	Integrated Risk Information System
Lead agency	The agency, either the EPA, Federal agency, or appropriate State agency having primary responsibility and authority for planning and executing the remediation at a site.
MCL	Maximum contaminant level: Established under the Safe Drinking Water Act.
MCLG	Maximum contaminant level goal: Established under the Safe Drinking Water Act.
MPRSA	Marine Protection Research and Sanctuaries Act
NAAQS	National Ambient Air Quality Standards
NCP	National Oil and Hazardous Substances Contingency Plan
NEPA	National Environmental Policy Act

NIOSH	National Institute for Occupational Safety and Health
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List: A list of sites identified for remediation under CERCLA.
O&M	Operation and maintenance
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
q_1^*	Cancer potency factor: The lifetime cancer risk for each additional mg/kg body weight per day of exposure.
PRP	Potentially responsible party
QA	Quality assurance
QAPP	Quality assurance project plan: A plan that describes protocols necessary to achieve the data quality objectives defined for an RI. (See SAP.)
QC	Quality control
RAS	Routine analytical services
RCRA	Resource Conservation and Recovery Act
RD	Remedial design
RfD	The reference dose (RfD) is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects during a lifetime.
RI/FS	Remedial investigation/ feasibility study
ROD	Record of Decision: Documents selection of cost-effective Superfund-financed remedy.
RPM	Remedial Project Manager: The project manager for the lead Federal agency.
SAP	Sampling and analysis plan, consisting of a quality assurance project plan (QAPP) and a field sampling plan (FSP).
SARA	Superfund Amendments and Reauthorization Act of 1986. (See CERCLA.)
SAS	Special analytical services
SDWA	Safe Drinking Water Act
SI	Site investigation
SITE	Superfund innovative technology evaluation
SOP	Standard operating procedures
SOW	Statement of Work
SPHEM	Superfund public health evaluation manual
SWDA	Solid Waste Disposal Act
TAT	Technical assistance team
TBC	To be considered
TCL	Target compound list
TDM	Technical directive memorandum
TSCA	Toxic Substances Control Act
WPRR	Work plan revision request

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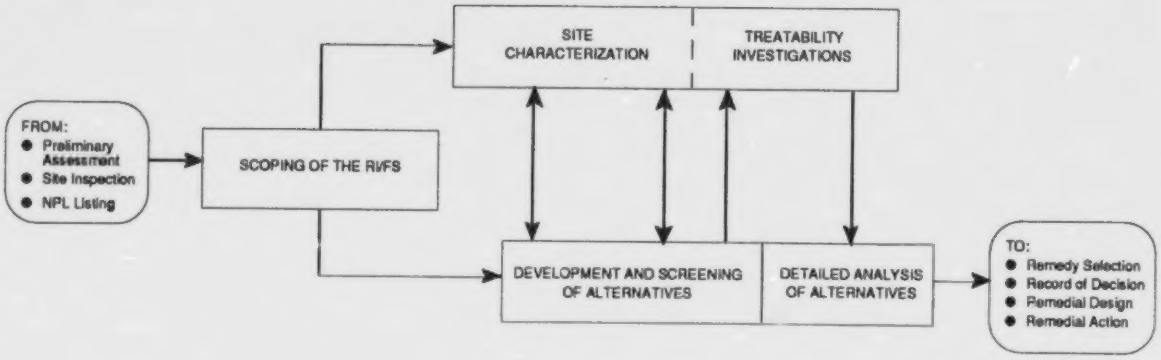
CHAPTER 1

INTRODUCTION


FROM:
Preliminary Assessment
Site Inspection
NPL Listing
SCOPING OF THE RI/FS
SITE CHARACTERIZATION
TREATABILITY INVESTIGATIONS
DEVELOPMENT AND SCREENING OF ALTERNATIVES
DETAILED ANALYSIS OF ALTERNATIVES
TO:
Remedy Selection
Record of Decision
Remedial Design
Remedial Action

Chapter 1
Introduction

1.1 Purpose of the RI/FS

The remedial investigation and feasibility study (RI/FS) process as outlined in this guidance represents the methodology that the Superfund program has established for characterizing the nature and extent of risks posed by uncontrolled hazardous waste sites and for evaluating potential remedial options. This approach should be viewed as a dynamic, flexible process that can and should be tailored to specific circumstances of individual sites; it is not a rigid step-by-step approach that must be conducted identically at every site. The project manager's central responsibility is to determine how best to use the flexibility built into the process to conduct an efficient and effective RI/FS that achieves high quality results in a timely and cost-effective manner. A significant challenge project managers face in effectively managing an RI/FS is the inherent uncertainties associated with the remediation of uncontrolled hazardous waste sites. These uncertainties can be numerous, ranging from potential unknowns regarding site hydrogeology and the actual extent of contamination, to the performance of treatment and engineering controls being considered as part of the remedial strategy. While these uncertainties foster a natural desire to want to know more, this desire competes with the Superfund program's mandate to perform cleanups within designated schedules.

The objective of the RI/FS process is not the unobtainable goal of removing *all* uncertainty, but rather to gather information sufficient to support an informed risk management decision regarding which remedy appears to be most appropriate for a given site. The appropriate level of analysis to meet this objective can only be reached through constant strategic thinking and careful planning concerning the essential data needed to reach a remedy selection decision. As hypotheses are tested and either rejected or confirmed, adjustments or choices as to the appropriate course for further investigations and analyses are required. These choices, like the remedy selection itself, involve the balancing of a wide variety of factors and the exercise of best professional judgment.

1.2 Purpose of the Guidance

This guidance document is a revision of the U.S. Environmental Protection Agency's (EPA) *Guidance on Remedial Investigations Under CERCLA* (May 1985) and *Guidance on Feasibility Studies Under CERCLA* (June 1985). These guidances have been consolidated into a single document and revised to (1) reflect new emphasis and provisions of the Superfund Amendments and Reauthorization Act (SARA), (2) incorporate aspects of new or revised guidance related to aspects of remedial investigations and feasibility studies (RI/FSs), (3) incorporate management initiatives designed to streamline the RI/FS process, and (4) reflect experience gained from previous RI/FS projects.

The purpose of this guidance is to provide the user with an overall understanding of the RI/FS process. Expected users include EPA personnel, State agencies responsible for coordinating or directing activities at National Priorities List (NPL) sites, potentially responsible parties (PRPs), Federal facility coordinators, and consultants or companies contracted to assist in RI/FS-related activities at NPL sites. This guidance describes the general procedures for conducting an RI/FS.[1] Where specific guidance is currently available elsewhere, the RI/FS guidance will simply highlight the key points or concepts as they relate to the RI/FS process and refer the user to the other sources for additional details.

1.3 Overview of CERCLA Reauthorization

SARA was signed by the President on October 17, 1986, to amend the Comprehensive Environmental Response, Compensation, and Liability Act of 1980

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[1] This guidance document does not typically address differences in the general procedures (e.g., work plan preparation, reporting requirements) between a Fund-financed and PRP-conducted RI/FS, and the flexibility discussed for certain activities may not pertain to a PRP-conducted RI/FS. Therefore, when PRPs are conducting an RI/FS, this guidance document must be used in conjunction with the "Interim Guidance on PRP Participation in the RI/FS Process" (see Appendix A).

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(CERCLA). While SARA did not change the basic structure of CERCLA, it did modify many of the existing requirements and added new ones. References made to CERCLA throughout this document should be interpreted as meaning "CERCLA as amended by SARA."

Many of the new provisions under CERCLA having the greatest impact on the RI/FS process are contained in §121 (Cleanup Standards). Other notable changes that also affect the RI/FS process are contained in §104 (Response Authorities, in particular Health-Related Authorities), portions of §104 and §121 regarding State involvement, §117 (Public Participation), §110 (Worker Protection Standards), and §113 (Civil Proceedings). Highlights of these sections are summarized below.

1.3.1 Cleanup Standards

Section 121 (Cleanup Standards) states a strong statutory preference for remedies that are highly reliable and provide long-term protection. In addition to the requirement for remedies to be both protective of human health and the environment and cost-effective, additional remedy selection considerations in §121(b) include:

- A preference for remedial actions that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous substances, pollutants, and contaminants as a principal element
- Offsite transport and disposal without treatment is the least favored alternative where practicable treatment technologies are available
- The need to assess the use of permanent solutions and alternative treatment technologies or resource recovery technologies and use them to the maximum extent practicable

Section 121(c) also requires a periodic review of remedial actions, at least every 5 years after initiation of such action, for as long as hazardous substances, pollutants, or contaminants that may pose a threat to human health or the environment remain at the site. If it is determined during a 5-year review that the action no longer protects human health and the environment, further remedial actions will need to be considered.

1.3.1.1 Applicable or Relevant and Appropriate Requirements

Section 121(d)(2)(A) of CERCLA incorporates into law the CERCLA Compliance Policy, which specifies that Superfund remedial actions meet any Federal standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate requirements (ARARs). Also included is the new provision that State ARARs must be met if they are more stringent than Federal requirements. Federal statutes that are specifically cited in CERCLA include the Solid Waste Disposal Act (SWDA), the Toxic Substances Control Act (TSCA), the Safe Drinking Water Act (SDWA), the Clean Air Act (CAA), the Clean Water Act (CWA), and the Marine Protection Research and Sanctuaries Act (MPRSA). Additional guidance on ARARs is provided in the "CERCLA Compliance with Other Statutes" manual (U.S. EPA, Draft, August 1988).

Section 121(d)(4) of CERCLA identifies six circumstances under which ARARs may be waived:

- The remedial action selected is only a part of a total remedial action (interim remedy) and the final remedy will attain the ARAR upon its completion.
- Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options.
- Compliance with the ARAR is technically impracticable from an engineering perspective.
- An alternative remedial action will attain an equivalent standard of performance through the use of another method or approach.
- The ARAR is a State requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.
- For §104 Superfund-financed remedial actions, compliance with the ARAR will not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities.

1.3.1.2 Offsite Facilities

The new statutory requirements contained in §121(d)(3) for acceptable offsite disposal facilities, in most respects, incorporate previous Agency policy. Offsite disposal facilities receiving contaminants must be in compliance with Resource Conservation and Recovery Act (RCRA) and other Federal and State laws. In addition, the unit receiving the waste must have no releases to ground water, surface water, or soil; other units that have had releases at the facility must be under an approved corrective action program.

1.3.2 Health Assessments

Under CERCLA §104(i) (Health-Related Authorities), the Agency for Toxic Substances and Disease

Registry (ATSDR) must conduct a health assessment for every site proposed for inclusion on the NPL. The purpose of these health assessments is to assist in determining whether current or potential risk to human health exists at a site and whether additional information on human exposure and associated health risks is needed. The health assessment is required to be completed "to the maximum extent practicable" before completion of the RI/FS.

1.3.3 State Involvement

Section 104(c)(3)(C) of CERCLA remains in effect requiring a 10-percent State cost share for remedial actions at privately operated sites and 50 percent at publicly operated sites.[2] Section 104(c)(3)(A) and 104(c)(6) of CERCLA provide that the operation and maintenance of ground- and surface-water restoration measures be considered part of remedial action for up to 10 years after commencement of operations or until remedial action is complete, whichever is earlier. Therefore, such activities during the 10-year period would be eligible for either 50 or 90 percent Federal funding depending on whether the site was publicly or privately operated.

Section 121(d)(2)(A) of CERCLA specifies that more stringent State ARARs apply if they are identified in a timely manner by the state. Section 121(f) requires EPA to develop regulations for substantial and meaningful State involvement in the remedial response process and specifies certain minimum requirements.

1.3.4 Community Involvement

Section 117 of CERCLA (Public Participation) emphasizes the importance of early, constant, and responsive relations with communities affected by Superfund sites and codifies, with some modifications, current community relations activities applied at NPL sites. Specifically, the law requires publication of a notice of any proposed remedial action (proposed plan) in a local newspaper of general circulation and a "reasonable opportunity" for the public to comment on the proposed plan and other contents of the administrative record, particularly the RI and the FS. In addition, the public is to be afforded an opportunity for a public meeting. The proposed plan should include a brief explanation of the alternatives considered, which will usually be in the form of a summary of the FS. Unlike the FS, however, the proposed plan will also provide an explanation of the preliminary preference for one of the options. Notice of the final plan adopted and an explanation of any significant changes from the proposed plan are also required. CERCLA also authorizes technical assistance grants for local citizens' groups potentially affected by an NPL site. The grants are to be used in obtaining assistance in interpreting information on the nature of hazards posed by the site, the results of the RI/FS, any removal actions, the Record of Decision (ROD), and the remedial design and remedial action.

1.3.5 Administrative Record

Section 113 of CERCLA requires that an administrative record be established "at or near the facility at issue." The record is to be compiled contemporaneously and must be available to the public and include all information considered or relied on in selecting the remedy, including public comments on the proposed plan.

1.3.6 Worker Safety

Section 126(c) of CERCLA directed the Occupational Safety and Health Administration (OSHA) to issue, within 60 days of the date of enactment of SARA, an interim final rule that contains employee protection requirements for workers engaged in hazardous waste operations. OSHA's interim final rule (29 CFR 1910.120) was published in the *Federal Register* on December 19, 1986, with full implementation of this rule required by March 16, 1987. The worker safety rule will remain in effect until the final standard is issued by OSHA and becomes effective.

1.3.7 Enforcement Authorities

Section 122(e) authorizes EPA to use "special notice" procedures, which for an RI/FS, establishes a 60-day moratorium period to provide time for formal negotiation between EPA and the PRPs for conduct of the RI/FS activities. This 60-day period may be extended to 90 days if within the 60-day time period, the potentially responsible parties (PRPs) provide EPA with a good faith offer to conduct or finance the RI/FS.

SARA allows for administrative consent orders to be signed using the authorities of Section 122(d)(3) as pertaining to Section 104(b) without having to make a finding of imminent and substantial endangerment. Section 104(a)(1) outlines special requirements for a PRP-lead RI/FS. These requirements include: making the determination that a PRP is qualified to perform the RI/FS; arranging for a third party to assist in oversight of the RI/FS; and requiring that PRPs pay for third party oversight.[3]

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[2] Remedial planning activities for the RI/FS and remedial design continue to be 100 percent federally funded.

[3] Specific guidance on PRP participation in the RI/FS process is found in Appendix A. Detailed guidance on PRP oversight is currently under preparation in the Office of Solid Waste and Emergency Response (OSWER).

1.4 The RI/FS Process Under CERCLA

Although the new provisions of CERCLA have resulted in some modifications to the RI/FS process, the basic components of the process remain intact. The RI continues to serve as the mechanism for collecting data to characterize site conditions; determine the nature of the waste; assess risk to human health and the environment; and conduct treatability testing as necessary to evaluate the potential performance and cost of the treatment technologies that are being considered. The latter also supports the design of selected remedies. The FS continues to serve as the mechanism for the development, screening, and detailed evaluation of alternative remedial actions.

The various steps, or phases, of the RI/FS process and how they have been modified to comply with the new provisions in CERCLA are summarized below. It is important to note that the RI and FS are to be conducted concurrently and that data collected in the RI influence the development of remedial alternatives in the FS, which in turn affects the data needs and scope of treatability studies and additional field investigations. Two concepts are essential to the phased RI/FS approach. First, data should generally be collected in several stages, with initial data collection efforts usually limited to developing a general understanding of the site. As a basic understanding of site characteristics is achieved, subsequent data collection efforts focus on filling identified gaps in the understanding of site characteristics and gathering information necessary to evaluate remedial alternatives. Second, this phased sampling approach encourages identification of key data needs as early in the process as possible to ensure that data collection is always directed toward providing information relevant to selection of a remedial action. In this way the overall site characterization effort can be continually scoped to minimize the collection of unnecessary data and maximize data quality.

Because of the interactive and iterative nature of this phase of the RI and FS process, the sequence of the various phases and associated activities, as described below and presented in Figure 1-1, will frequently be less distinct in practice. A generic timeline intended to illustrate the phasing of RI/FS activities is presented in Figure 1-2. The actual timing of individual activities will depend on specific site situations.

1.4.1 Scoping

Scoping is the initial planning phase of the RI/FS process, and many of the planning steps begun here are continued and refined in later phases of the RI/FS. Scoping activities typically begin with the collection of existing site data, including data from previous investigations such as the preliminary assessment and site investigation. On the basis of this information, site management planning is undertaken to preliminarily identify boundaries of the study area, identify likely remedial action objectives and whether interim actions may be necessary or appropriate, and to establish whether the site may best be remedied as one or several separate operable units. Once an overall management strategy is agreed upon, the RI/ FS for a specific project or the site as a whole is planned. Typical scoping activities include:

- Initiating the identification and discussion of potential ARARs with the support agency
- Determining the types of decisions to be made and identifying the data and other information needed to support those decisions
- Assembling a "technical advisory committee" to assist in these activities, to serve as a review board for important deliverables, and to monitor progress, as appropriate, during the study
- Preparing the work plan, the sampling and analysis plan (SAP) (which consists of the quality assurance project plan (QAPP) and the field sampling plan (FSP)), the health and safety plan, and the community relations plan

Chapter 2 describes the various steps in the scoping process and gives general information on work-planning methods that have been effective in planning and executing past RI/FSs.

1.4.2 Site Characterization

During site characterization, field sampling and laboratory analyses are initiated. Field sampling should be phased[4] so that the results of the initial sampling efforts can be used to refine plans developed during scoping to better focus subsequent sampling efforts. Data quality objectives are revised as appropriate based on an improved understanding of the site to facilitate a more efficient and accurate characterization of the site and, therefore, achieve reductions in time and cost.

A preliminary site characterization summary is prepared to provide the lead agency with information on the site early in the process before preparation of the full RI report. This summary will be useful in determining the feasibility of potential technologies and in assisting both the lead and support agencies with the initial identification of ARARs. It can also be

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[4] Emphasis is placed on rapid turnaround of sampling results to avoid the need to remobilize and reprocure contractors.

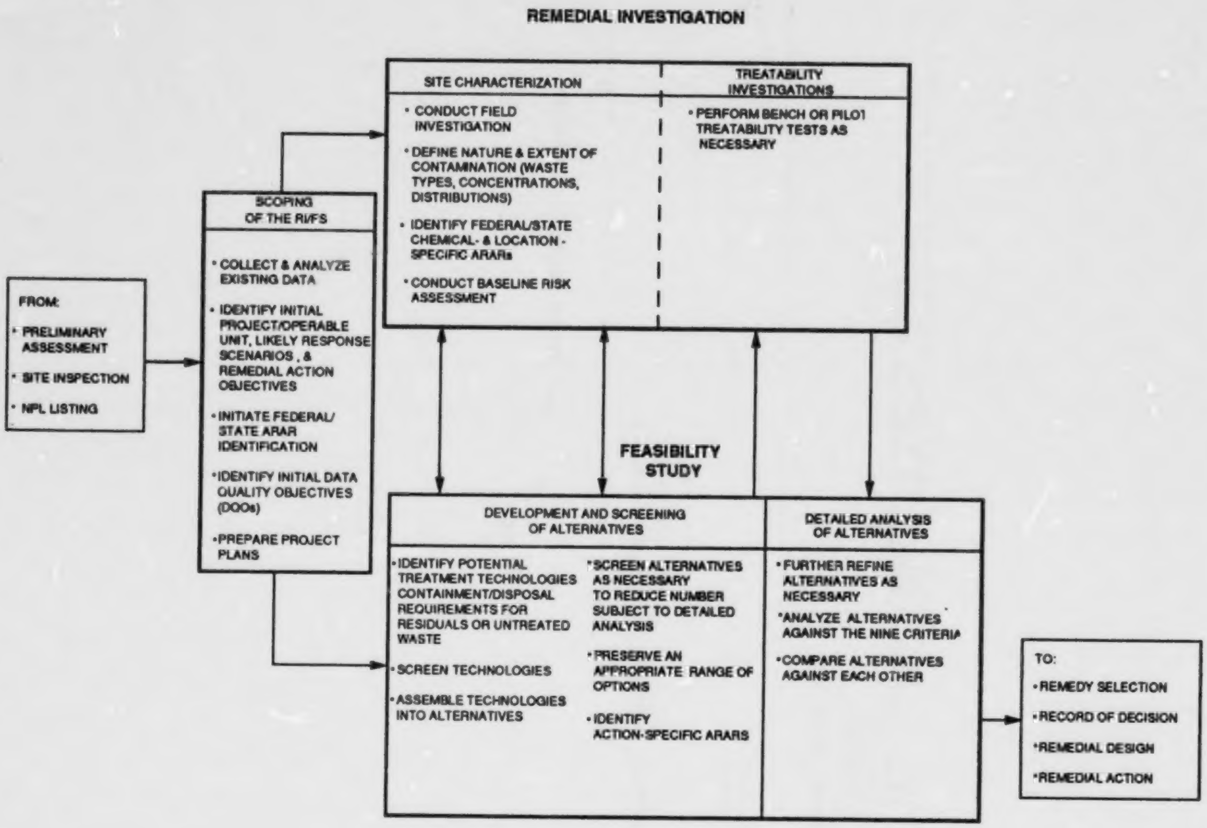
REMEDIAL INVESTIGATION
SITE CHARACTERIZATION
• CONDUCT FIELD INVESTIGATION
• DEFINE NATURE & EXTENT OF CONTAMINATION (WASTE TYPES, CONCENTRATIONS, DISTRIBUTIONS)
• IDENTIFY FEDERAL/STATE CHEMICAL- & LOCATION - SPECIFIC ARARs
• CONDUCT BASELINE RISK ASSESSMENT
TREATABILITY INVESTIGATIONS
• PERFORM BENCH OR PILOT TREATABILITY TESTS AS NECESSARY
SCOPING OF THE RI/FS
• COLLECT & ANALYZE EXISTING DATA
• IDENTIFY INITIAL PROJECT/OPERABLE UNIT, LIKELY RESPONSE SCENARIOS, & REMEDIAL ACTION OBJECTIVES
• INITIATE FEDERAL/ STATE ARAR IDENTIFICATION
• IDENTIFY INITIAL DATA QUALITY OBJECTIVES (DQOs)
• PREPARE PROJECT PLANS
FROM:
• PRELIMINARY ASSESSMENT
• SITE INSPECTION
• NPL LISTING
FEASIBILITY STUDY
DEVELOPMENT AND SCREENING OF ALTERNATIVES
• IDENTIFY POTENTIAL TREATMENT TECHNOLOGIES CONTAINMENT/DISPOSAL REQUIREMENTS FOR RESIDUALS OR UNTREATED WASTE
• SCREEN TECHNOLOGIES
• ASSEMBLE TECHNOLOGIES INTO ALTERNATIVES
• SCREEN ALTERNATIVES AS NECESSARY TO REDUCE NUMBER SUBJECT TO DETAILED ANALYSIS
• PRESERVE AN APPROPRIATE RANGE OF OPTIONS
• IDENTIFY ACTION-SPECIFIC ARARS
DETAILED ANALYSIS OF ALTERNATIVES
• FURTHER REFINE ALTERNATIVES AS NECESSARY
• ANALYZE ALTERNATIVES AGAINST THE NINE CRITERIA
• COMPARE ALTERNATIVES AGAINST EACH OTHER
TO:
• REMEDY SELECTION
• RECORD OF DECISION
• REMEDIAL DESIGN
• REMEDIAL ACTION

Figure 1-1. Phased RI/FS Process. .

sent to ATSDR to assist them in performing their health assessment of the site.

A baseline risk assessment is developed to identify the existing or potential risks that may be posed to human health and the environment by the site. This assessment also serves to support the evaluation of the no-action alternative by documenting the threats posed by the site based on expected exposure scenarios. Because this assessment identifies the primary health and environmental threats at the site, it also provides valuable input to the development and evaluation of alternatives during the FS. Site characterization activities are described in Chapter 3.

1.4.3 *Development and Screening of Alternatives*

The development of alternatives usually begins during or soon after scoping, when likely response scenarios may first be identified. The development of alternatives requires (1) identifying remedial action objectives; (2) identifying potential treatment, resource recovery, and containment technologies that will satisfy these objectives; (3) screening the technologies based on their effectiveness, implementability, and cost; and (4) assembling technologies and their associated containment or disposal requirements into alternatives for the contaminated media at the site or for the operable unit. Alternatives can be developed to address contaminated medium (e.g., ground water), a specific area of the site (e.g., a waste lagoon or contaminated hot spots), or the entire site. Alternatives for specific media and site areas either can be carried through the FS process separately or combined into comprehensive alternatives for the entire site. The approach is flexible to allow alternatives to be combined at various points in the process.

As practicable, a range of treatment alternatives should be developed, varying primarily in the extent to which they rely on long-term management of residuals and untreated wastes. The upper bound of the range would be an alternative that would eliminate, to the extent feasible, the need for any long-term management (including monitoring) at the site. The lower bound would consist of an alternative that involves treatment as a principal element (i.e., treatment is used to address the principal threats at

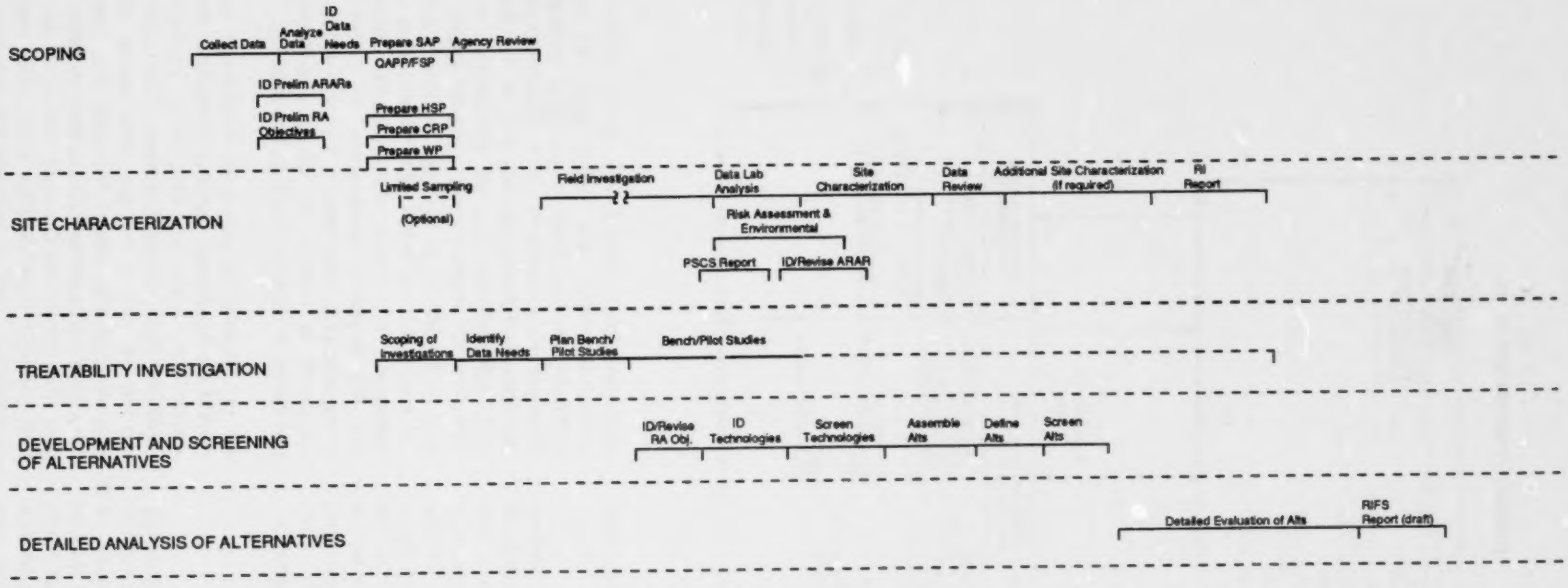
SCOPING
Collect Data
Analyze Data
ID Data Needs
Prepare SAP
QAPP/FSP
Agency Review
ID Prelim ARARs
ID Prelim RA Objectives
Prepare HSP
Prepare CRP
Prepare WP
SITE CHARACTERIZATION
Limited Sampling
(Optional)
Field Investigation
Data Lab Analysis
Site Characterization
Data Review
Additional Site Characterization (if required)
RI Report
Risk Assessment & Environmental
PSCS Report
ID/Revise ARAR
TREATABILITY INVESTIGATION
Scoping of Investigations
Identify Data Needs
Plan Bench/ Pilot Studies
Bench/Pilot Studies
DEVELOPMENT AND SCREENING OF ALTERNATIVES
ID/Revise RA Obj.
ID Technologies
Screen Technologies
Assemble Alts
Define Alts
Screen Alts
DETAILED ANALYSIS OF ALTERNATIVES
Detailed Evaluation of Alts
RI/FS Report (draft)

Figure 1-2. **Generic Phased RI/FS Timeline.**

the site), but some long-term management of portions of the site that did not constitute "principal threats" would be required. Between the upper and lower bounds of the treatment range, alternatives varying in the type and degrees of treatment and associated containment/ disposal requirements should be included as appropriate. In addition, one or more containment option(s) involving little or no treatment should be developed as appropriate, and a no-action alternative should always be developed.

Once potential alternatives have been developed, it may be necessary to screen out certain options to reduce the number of alternatives that will be analyzed in detail in order to minimize the resources dedicated to evaluating options that are less promising. The necessity of this screening effort will depend on the number of alternatives initially developed, which will depend partially on the complexity of the site and/ or the number of available, suitable technologies. For situations in which it is necessary to reduce the initial number of alternatives before beginning the detailed analysis, a range of alternatives should be preserved, as practicable, so that the decisionmaker can be presented with a variety of distinct, viable options from which to choose. The screening process involves evaluating alternatives with respect to their effectiveness, implementability, and cost. It is usually done on a general basis and with limited effort (relative to the detailed analysis) because the information necessary to fully evaluate the alternatives may not be complete at this point in the process. The development and screening of alternatives is discussed in Chapter 4.

1.4.4 Treatability Investigations

Should existing site and/or treatment data be insufficient to adequately evaluate alternatives, treatability tests may be necessary to evaluate a particular technology on specific site wastes. Generally, treatability tests involve bench-scale testing to gather information to assess the feasibility of a technology. In a few situations, a pilot-scale study may be necessary to furnish performance data and develop better cost estimates so that a detailed analysis can be performed and a remedial action can be selected. To conduct a pilot-scale test and keep the RI/ FS on schedule, it will usually be necessary to identify and initiate the test at an early point in the process. Treatability investigations are described in Chapter 5.

1.4.5 Detailed Analysis

Once sufficient data are available, alternatives are evaluated in detail with respect to nine evaluation criteria that the Agency has developed to address the statutory requirements and preferences of CERCLA. The alternatives are analyzed individually against each criterion and then compared against one another to determine their respective strengths and weaknesses and to identify the key tradeoffs that must be balanced for that site. The results of the detailed analysis are summarized and presented to the decisionmaker so that an appropriate remedy consistent with CERCLA can be selected. The detailed analysis of alternatives is described in Chapter 6.

1.5 Special Sites

The use of treatment technologies and, therefore, the development of a complete range of options, may not be practicable at some sites with large volumes of low concentration wastes (e.g., large municipal landfills or mining sites). Remedies involving treatment at such sites may be prohibitively expensive or difficult to implement. Therefore, the range of alternatives initially developed may be focused primarily on various containment options. Although this guidance does not specifically state how all such sites should be addressed, factors are discussed that can be used, as appropriate, to help guide the development and evaluation of alternatives on a case-by-case basis.

1.6 Community Relations

Community relations is a useful and important aspect of the RI/FS process. Community relations activities serve to keep communities informed of the activities at the site and help the Agency anticipate and respond to community concerns. A community relations plan is developed for a site as the work plan for the RI/FS is prepared. The community relations plan is based on interviews with interested people in the community and will provide the guidelines for future community relations activities at the site. At a minimum, the plan must provide for a site mailing list, a conveniently located place for access to all public information about the site, an opportunity for a public meeting when the RI/FS report and proposed plan are issued, and a summary of public comments on the RI/FS report and proposed plan and the Agency's response to those comments.

The specific community relations requirements for each phase of the RI/FS are integrated throughout this guidance document since they are parallel to and support the technical activities. Each chapter of this guidance has a section discussing community relations requirements appropriate to that specific phase of the RI/FS. Additional program requirements are described in the draft of *Community Relations in Superfund: A Handbook* (U.S. EPA, Interim, June 1988).

1.7 Lead and Support Agency

Throughout this guidance the terms "lead agency" and "support agency" are used to reflect the fact that either EPA or a State or Federal facility can have the lead responsibility for conducting an RI/FS. The support agency plays a review and concurrence role and provides specific information as necessary to the lead agency (e.g., ARAR identification). The roles of the lead and support agencies in each phase of the RI/FS process are described at the end of each chapter.

1.8 Remedial Project Manager Role and Responsibilities

The Remedial Project Manager's (RPM's) role in overseeing an RI/FS involves, to a large extent, ensuring that the work progresses according to the priorities and objectives established during site management and project planning. This role requires planning project scopes early and deriving cost estimates for the specific tasks and activities described in the Statement of Work (SOW).[5] It is the RPM's responsibility to develop realistic cost estimates, monitor and control contractor expenditures, and manage changing site conditions within the allocated budget. The RPM facilitates the interactions among EPA staff, State representatives, contractor personnel, PRPs, and the public to ensure that all involved parties are aware of their roles and responsibilities. Throughout the following chapters, and particularly in the discussions of scoping (Chapter 2) and site characterization (Chapter 3), suggestions are provided to guide the RPM in developing approaches for conducting RI/FSs so that high-quality deliverables are produced in a timely and cost-effective manner. Additional suggestions specific to management of RI/FSs may be found in the *Superfund Federal-Lead Remedial Project Management Handbook* (U.S. EPA, December 1986) and *Superfund State-Lead Remedial Project Management Handbook* (U.S. EPA, December 1986). Oversight responsibilities for PRP-lead RI/FSs are outlined in Appendix A of this guidance.

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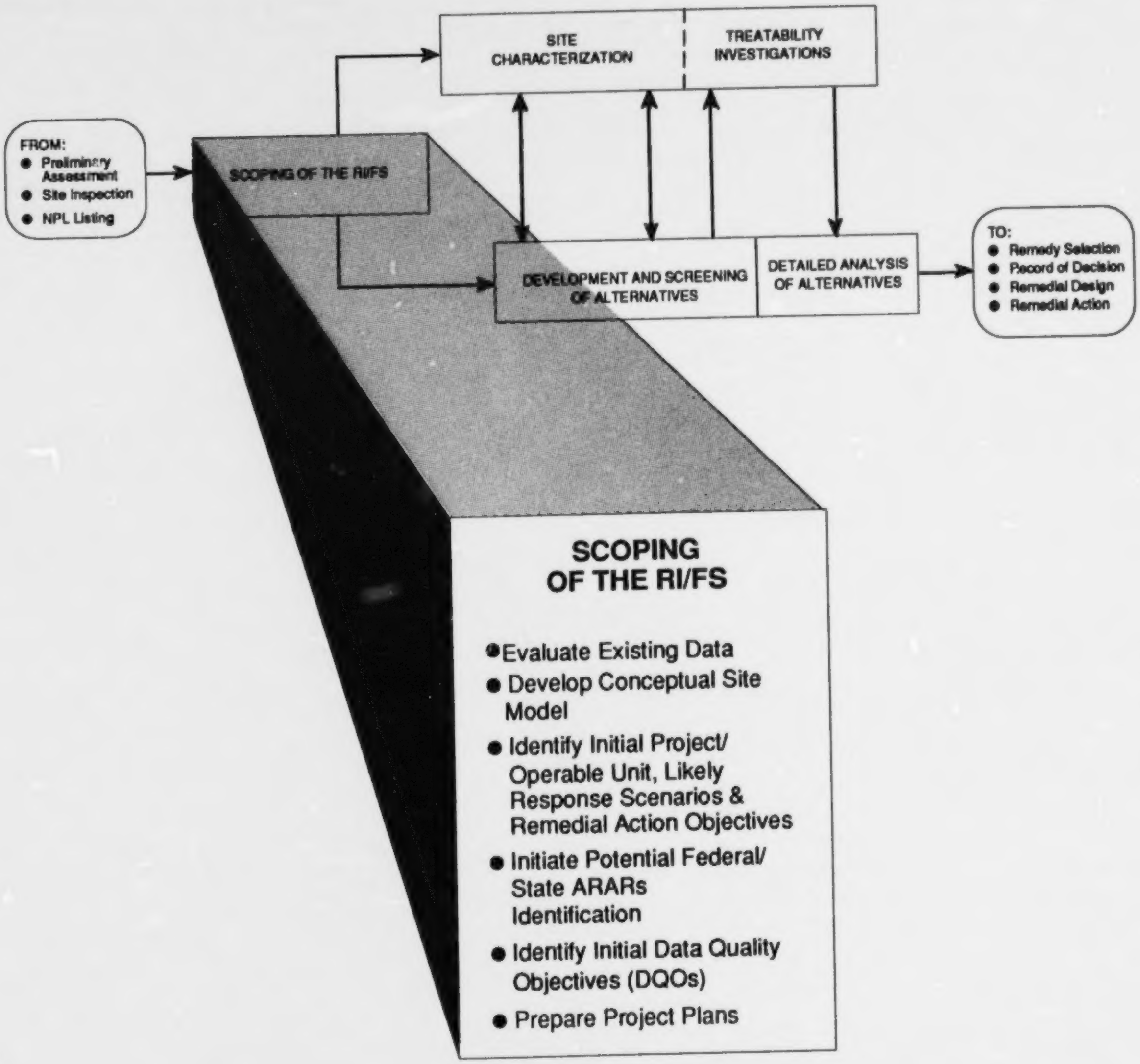
[5] OSWER is developing cost estimating guides and a reference document for use by RPMs that will provide historical averages for the cost of the various RI/FS tasks.

CHAPTER 2

SCOPING OF THE RI/FS


FROM:
Preliminary Assessment
Site Inspection
NPL Listing
SCOPING OF THE RI/FS
SITE CHARACTERIZATION
TREATABILITY INVESTIGATIONS
DEVELOPMENT AND SCREENING OF ALTERNATIVES
DETAILED ANALYSIS OF ALTERNATIVES
TO:
Remedy Selection
Record of Decision
Remedial Design
Remedial Action

SCOPING OF THE RI/FS

- Evaluate Existing Data
- Develop Conceptual Site Model
- Identify Initial Project/ Operable Unit, Likely Response Scenarios & Remedial Action Objectives
- Initiate Potential Federal/ State ARARs Identification
- Identify Initial Data Quality Objectives (DQOs)
- Prepare Project Plans

Chapter 2
Scoping the RI/FS

2.1 Introduction

Scoping is the initial planning phase of site remediation and is begun, at least informally, by the lead agency's RPM as part of the funding allocation and planning process. The lead and support agencies should meet and, on the basis of available information, begin to (1) identify the types of actions that may be required to address site problems; (2) identify whether interim actions are necessary or appropriate to mitigate potential threats, prevent further environmental degradation, or rapidly reduce risks significantly, and (3) identify the optimal sequence of site actions and investigative activities.

Once the lead and support agencies initially agree on a general approach for managing the site, the next step is to scope the project(s) and develop specific project plans. Project planning is done to:

- Determine the types of decisions to be made
- Identify the type and quality of data quality objectives (DQOs) needed to support those decisions
- Describe the methods by which the required data will be obtained and analyzed
- Prepare project plans to document methods and procedures

The activities described above relate directly to the establishment of DQOs – statements that specify the type and quality of the data needed to support decisions regarding remedial response activities. The establishment of DQOs is discussed in detail in *Data Quality Objectives for Remedial Response Activities* (U.S. EPA, March 1987, hereafter referred to as the *DQO Guidance*).

The ability to adequately scope a specific project is closely tied to the amount and quality of available information. Therefore, it is important to note that the scope of the project and, to some extent the specific project plans, are developed iteratively (i.e., as new information is acquired or new decisions are made, data requirements are reevaluated and, if appropriate, project plans are modified). In this way, scoping helps to focus activities and streamline the RI/FS, thereby preventing needless expenditures and loss of time in unnecessary sampling and analyses.

Figure 2-1 shows the key steps in the scoping process.[1]

2.2 Project Planning

Once a general site management approach has been agreed upon, planning can begin for the scope of a specific project. The specific activities conducted during project planning include:[2]

- Meeting with lead agency, support agency, and contractor personnel to discuss site issues and assign responsibilities for RI/FS activities
- Collecting and analyzing existing data to develop a conceptual site model that can be used to assess both the nature and the extent of contamination and to identify potential exposure pathways and potential human health and/or environmental receptors
- Initiating limited field investigations if available data are inadequate to develop a conceptual site model and adequately scope the project
- Identifying preliminary remedial action objectives and likely response actions for the specific project
- Preliminarily identifying the ARARs expected to apply to site characterization and site remediation activities
- Determining data needs and the level of analytical and sampling certainty required for additional data

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[1] See Appendix A for a delineation of responsibilities between the lead agency and the PRPs during the scoping process.

[2] For a PRP-lead RI/FS the PRPs are typically responsible for these activities except for conducting community interviews. This responsibility rests with the lead agency. Specific activities performed by the PRPs during scoping are determined during the negotiation period and should be specified in the agreement between the PRPs and the lead agency.

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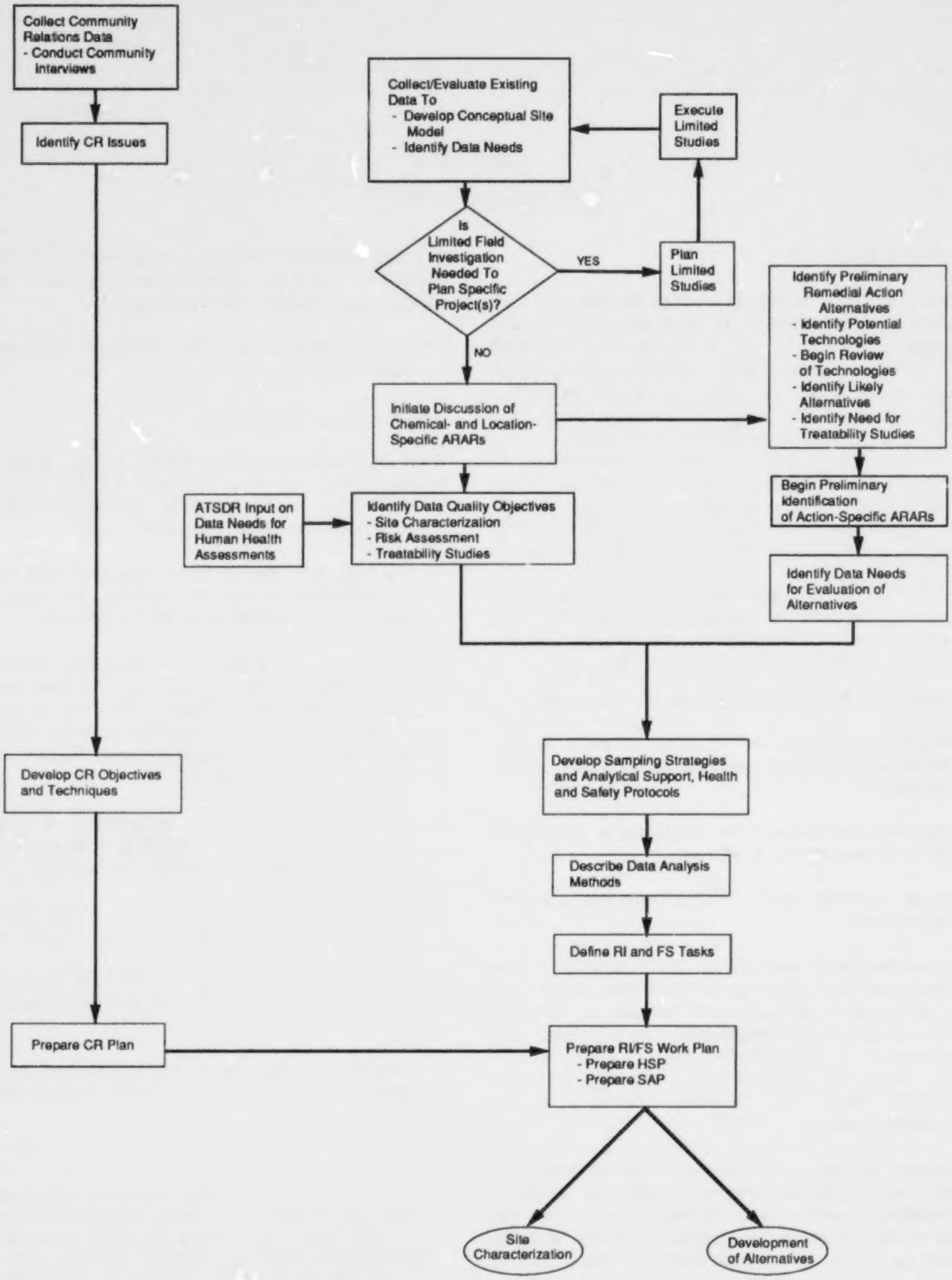
Collect Community Relations Data
- Conduct Community Interviews
Identify CR Issues
Develop CR Objectives and Techniques
Prepare CR Plan
Collect/Evaluate Existing Data To
- Develop Conceptual Site Model
- Identify Data Needs
Execute Limited Studies
Is Limited Field Investigation Needed To Plan Specific Project(s)?
YES
Plan Limited Studies
NO
Initiate Discussion of Chemical- and Location-Specific ARARs
Identify Preliminary Remedial Action Alternatives
- Identify Potential Technologies
- Begin Review of Technologies
- Identify Likely Alternatives
- Identify Need for Treatability Studies
ATSDR Input on Data Needs for Human Health Assessments
Identify Data Quality Objectives
- Site Characterization
- Risk Assessment
- Treatability Studies
Begin Preliminary Identification of Action-Specific ARARs
Identify Data Needs for Evaluation of Alternatives
Develop Sampling Strategies and Analytical Support, Health and Safety Protocols
Describe Data Analysis Methods
Define RI and FS Tasks
Prepare RI/FS Work Plan
- Prepare HSP
- Prepare SAP
Site Characterization
Development of Alternatives

Figure 2-1. **Scoping.**

if currently available data are inadequate to conduct the FS

- Identifying the need and the schedule for treatability studies to better evaluate potential remedial alternatives

- Designing a data collection program to describe the selection of the sampling approaches and analytical options. (This selection is documented in the SAP, which consists of the FSP and QAPP elements.)

- Developing a work plan that documents the scoping process and presents anticipated future tasks

- Identifying and documenting health and safety protocols required during field investigations and preparing a site health and safety plan

- Conducting community interviews to obtain information that can be used to develop a site-specific community relations plan that documents the objectives and approaches of the community relations program

2.2.1 Conduct Project Meeting

To begin project planning, a meeting should be held involving key management from the lead and support agencies. The purpose of this meeting is to allow key personnel to become involved in initial planning decisions and give them the opportunity to discuss any special concerns that may be associated with the site. Furthermore, this meeting should set a precedent for the involvement of key personnel periodically throughout the project. Additional attendees should include contractor personnel who will be conducting the RI/FS and performing the risk assessment, Natural Resource Trustee representatives, when applicable, and individuals with prior experience at the site [e.g., the field investigation team (FIT)] or other similar sites who may be able to provide additional insight into effective techniques for addressing potential site problems.

2.2.2 Collect and Analyze Existing Data

Before the activities necessary to conduct an RI/FS can be planned, it is important to compile the available data that have previously been collected for a site. These data can be used to determine the additional work that needs to be conducted both in the field and within the community. A thorough search of existing data should help avoid duplication of previous efforts and lead to a remedial investigation that is more focused and, therefore, more efficient in its expenditure of resources.

Information describing hazardous waste sources, migration pathways, and human and environmental receptors for a given site is available from many sources. Some of the more useful sources are listed in Table 2-1. Site investigation (SI) data[3] gathered in the hazard ranking process (the process by which a site is listed on the NPL) may be located in files maintained by the EPA Regional offices, the FIT, the technical assistance team (TAT), contractors, and the state.

Data relating to the varieties and quantities of hazardous wastes disposed of at the site should be compiled. The results from any previous sampling events should be summarized in terms of physical and chemical characteristics, contaminants identified, and their respective concentrations. Results of environmental sampling at the site should be summarized, and evidence of soil, ground water, surface water, sediment, air, or biotic contamination should be documented. If available, information on the precision and accuracy of the data should be included.

Records of disposal practices and operating procedures at the site, including historical photographs, can be reviewed to identify locations of waste materials onsite, waste haulers, and waste generators. If specific waste records are absent, waste products that may have been disposed of at the site can be identified through a review of the manufacturing processes of the waste generators.

A summary of existing site-specific and regional information should be compiled to help identify surface, subsurface, atmospheric, and biotic migration pathways. Compiled information should include geology, hydrogeology, hydrology, meteorology, and ecology. Regional information can help to identify background soil, water, and air quality characteristics. Data on human and environmental receptors in the area surrounding the site should be compiled. Demographic and land use information will help identify potential human receptors. Residential, municipal, or industrial wells should be located, and surface water uses should be identified for surrounding areas and areas downstream of the site.

Existing information describing the common flora and fauna of the site and surrounding areas should be collected. The location of any threatened, endangered, or rare species, sensitive environmental areas, or critical habitats on or near the site should be identified. Available results from any previous biological testing should be compiled to document

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[3] The expanded site investigation (ESI) conducted by the pre-remedial program will provide valuable data (e.g., geophysics, surveys, well inventories) and should serve as an important source of information during the scoping process for establishing the hypotheses to be tested concerning the nature and extent of contamination.

Table 2-1. Data Collection Information Sources

Information Source	Hazardous Waste Sources	Migration Pathways Subsurface	Migration Pathways Surface	Migration Pathways Air	Receptors
U.S. EPA Files	X	X	X	X	X
U.S. Geological Survey		X	X		
U.S. DOA, Soil Conservation Service[a]		X	X		
U.S. DOA, Agricultural Stabilization and Conservation Service		X	X		
U.S. DOA, Forest Service			X		X
U.S. DOI, Fish and Wildlife Agencies					X
U.S. DOI, Bureau of Reclamation	X	X	X		
U.S. Army Corps of Engineers	X				
Federal Emergency Management Agency[b]			X		
U.S. Census Bureau					X
National Oceanic and Atmospheric Administration				X	
State Environmental Protection or Public Health Agencies	X	X	X	X	X
State Geological Survey		X	X		
State Fish and Wildlife Agencies					X
Local Planning Boards		X	X	X	X
County or City Health Departments	X	X	X	X	X
Town Engineer or Town Hall	X				X
Local Chamber of Commerce	X				X
Local Airport				X	
Local Library		X			X
Local Well Drillers		X			
Sewage Treatment Plants	X	X	X		
Local Water Authorities		X			X
City Fire Departments	X	X	X	X	
Regional Geologic and Hydrologic Publications		X	X		
Court Records of Legal Action	X				
Department of Justice Files	X				
State Attorney General Files	X				
Facility Records	X				
Facility Owners and Employees[c]	X	X			X
Citizens Residing Near Site[c]	X	X	X	X	X
Waste Haulers and Generators[c]	X				
Site Visit Reports	X		X	X	X
Photographs	X		X		X
Preliminary Assessment Report	X	X	X	X	X
Field Investigation Analytical Data	X	X	X	X	
FIT/TAT Reports	X	X	X	X	X
Site Inspection Report	X	X	X	X	X
HRS Scoring Package	X	X	X	X	X
EMSL/EPIC (Environmental Monitoring Support Laboratory/ Environmental Photographic Information Center)	X		X		X

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[a] Includes county soil survey reports from Soil Conservation Service, U.S. DOA.

[b] The Federal Emergency Management Agency publishes floodplain maps.

[c] Interviews require lead agency concurrence.

any known ecological effect such as acute or chronic toxicity or bioaccumulation in the food chain.

Once the available data have been collected, they are analyzed to (1) establish the physical characteristics of a site to help determine the scope of future sampling efforts; and (2) conceptually model potential exposure pathways and receptors to assist in the preliminary assessment of risk and the initial identification of potential remedial technologies. Each of these uses is discussed below.

2.2.2.1 Establish Physical Characteristics of the Site

The analysis of existing data serves to provide a better understanding of the nature and extent of contamination and aids in the design of remedial investigation tasks. If quality assurance information on existing sampling data is available, it should be reviewed to assess the level of uncertainty associated with the data. This is important to establish whether sampling will be needed to verify or simply supplement existing data. Important factors to consider when reviewing existing data are the comparability of the data (e.g., time of sampling), the analytical methods, the detection limits, the analytical laboratories, and the sample collection and handling methods.[4]

Existing data should be used to develop a site description, which should include location, ownership, topography, geology, land use, waste type, estimates of waste volume, and other pertinent details. The site description should also include a chronology of significant events such as chemical storage and disposal practices, previous site visits, sampling events, regulatory violations, legal actions, and changes in ownership. In addition, information concerning previous cleanup actions, such as removal of containerized waste, is often valuable for determining the characteristics of any wastes or contaminated media remaining at the site. All sources of information or data should be summarized in a technical memorandum or retained for inclusion in the RI report.

2.2.2.2 Develop a Conceptual Site Model

Information on the waste sources, pathways, and receptors at a site is used to develop a conceptual understanding of the site to evaluate potential risks to human health and the environment. The conceptual site model should include known and suspected sources of contamination, types of contaminants and affected media, known and potential routes of migration, and known or potential human and environmental receptors. This effort, in addition to assisting in identifying locations where sampling is necessary, will also assist in the identification of potential remedial technologies. Additional information for evaluating exposure concerns through the use of a conceptual model is provided in the *DQO Guidance*. An example of a conceptual model is provided in Figure 2-2.

2.2.2.3 Determine the Need for and Implement Limited Additional Studies

If the conceptual understanding of a site is poor and the collection of site-specific data would greatly enhance the scoping effort, a limited field investigation may be undertaken as an interim scoping task prior to developing the work plan.[5] Normally, the investigation is limited to easily obtainable data, where results can be achieved in a short time. Examples of tasks are as follows:

- Preliminary geophysical investigations
- Residential, industrial, and agricultural well sampling and analysis
- Measurement of well-water level, sampling (only for pre-existing monitoring wells), and analysis
- Limited sampling to determine the need for waste treatability studies
- Air monitoring
- Site mapping
- Preliminary ecological reconnaissance

2.2.3 Develop Preliminary Remedial Action Alternatives

Once the existing site information has been analyzed and a conceptual understanding of the site is obtained, potential remedial action objectives should be identified for each contaminated medium (Chapter 4 presents examples of remedial action objectives) and a preliminary range of remedial action alternatives and associated technologies should be identified. This identification is not meant to be a detailed investigation of alternatives. Rather, it is intended to be a more general classification of potential remedial actions based upon the initially identified potential routes of exposure and associated receptors. The identification of potential technologies at this stage will help ensure that data needed to evaluate them (e.g.,

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[4] Regardless of the origin and quality of existing data, they typically are useful in constructing hypotheses concerning the nature and extent of contamination.

[5] The specific procedures for initiating limited field investigation will be dependent on the lead agency's administrative and contractual requirements.

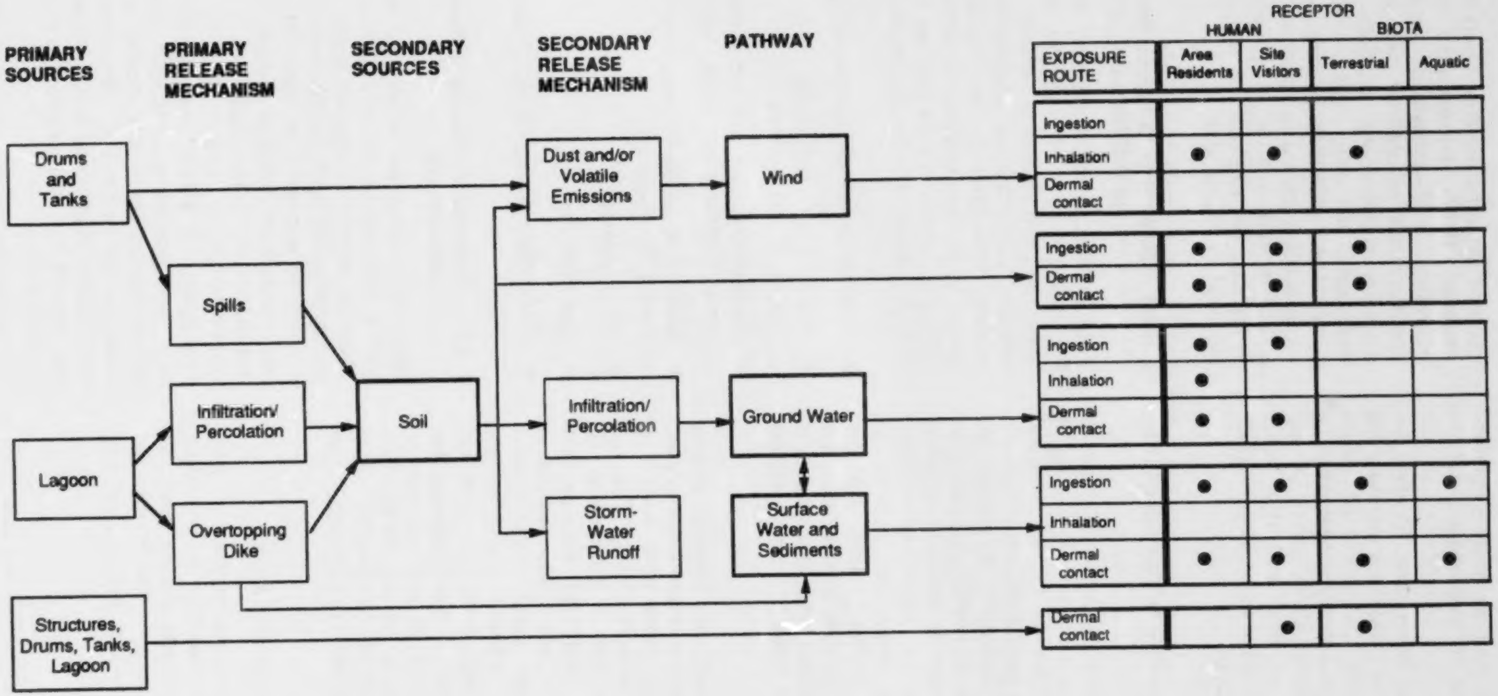
PRIMARY SOURCES
PRIMARY RELEASE MECHANISM
SECONDARY SOURCES
SECONDARY RELEASE MECHANISM
PATHWAY
RECEPTOR
HUMAN
BIOTA
EXPOSURE ROUTE
Area Residents
Site Visitors
Terrestrial
Aquatic
Drums and Tanks
Lagoon
Structures, Drums, Tanks, Lagoon
Spills
Infiltration/ Percolation
Overtopping Dike
Soil
Dust and/or Volatile Emissions
Infiltration/ Percolation
Storm-Water Runoff
Wind
Ground Water
Surface Water and Sediments
Ingestion
Inhalation
Dermal contact
Ingestion
Dermal contact
Ingestion
Inhalation
Dermal contact
Ingestion
Inhalation
Dermal contact
Dermal contact

Figure 2-2. Example Conceptual Site Model.

Btu value of wastes to evaluate thermal destruction capabilities) can be collected as early as possible. In addition, the early identification of technologies will allow earlier determinations as to the need for treatability studies.

Technologies that may be appropriate for treating or disposing of wastes should be identified along with sources of literature on the technologies' effectiveness, applications, and cost. Further assistance in the investigation of technologies is provided in the *Technology Screening Guide for Treatment of CERCLA Soils and Sludges* (U.S. EPA, September 1988). Innovative technologies and resource recovery options should be included if they appear feasible.

To the extent practicable, a preliminary list of broadly defined alternatives should be developed that reflects the goal of presenting a range of distinct, viable options to the decision-maker. This list would therefore include as appropriate a range of alternatives in which treatment that significantly reduces the toxicity, mobility, or volume of waste is a principal element; one or more alternatives that involve containment with little or no treatment; and a no-action alternative. The list should be limited to only those alternatives that are relevant and carry some significant potential for being implemented at the site. In this way, the preliminary identification of remedial actions will allow an initial identification of ARARs and will help focus subsequent data-gathering efforts.

Involvement of the various agencies at this time will help in identifying remedial alternatives and scoping field activities. The development of alternatives is described in more detail in Chapter 4 of this document.

2.2.4 Evaluate the Need for Treatability Studies

If remedial actions involving treatment have been identified for a site, then the need for treatability studies should be evaluated as early as possible in the RI/FS process. This is because many treatability studies, especially pilot testing, may take several months or longer to complete. If a lengthy study is required and is not initiated early, completion of the FS may be delayed.

The initial activities of treatability testing include researching other potentially applicable data, designing the study, and procuring vendors and equipment. As appropriate, these activities should occur concurrently with site characterization efforts so that if it is determined that a potential technology is not feasible, planned treatability activities for this technology can be terminated. Chapter 5 provides guidance on scoping treatability studies.

2.2.5 Begin Preliminary Identification of ARARs and To Be Considered (TBC) Information

A preliminary identification of potential ARARs and TBC information in the scoping phase can assist in initially identifying remedial alternatives and is useful for initiating communications with the support agency to facilitate the identification of ARARs. Furthermore, early identification of potential ARARs will allow better planning of field activities.[6] Because of the iterative nature of the RI/FS process, ARAR identification continues throughout the RI/FS as a better understanding is gained of site conditions, site contaminants, and remedial action alternatives.

ARARs may be categorized as chemical-specific requirements that may define acceptable exposure levels and therefore be used in establishing preliminary remediation goals; as location-specific requirements that may set restrictions on activities within specific locations such as floodplains or wetlands; and as action-specific, which may set controls or restrictions for particular treatment and disposal activities related to the management of hazardous wastes. The document, "CERCLA Compliance with Other Laws Manual" (U.S. EPA, Draft, May 1988), contains detailed information on identifying and complying with ARARs.

Potential chemical- and location-specific ARARs are identified on the basis of the compilation and evaluation of existing site data. A preliminary evaluation of potential action-specific ARARs may also be made to assess the feasibility of remedial technologies being considered at this time. In addition to federal ARARs, more stringent state ARARs must also be identified. Other federal and state criteria, advisories, and guidance and local ordinances should also be considered, as appropriate, in the development of remedial action alternatives.

For documentation purposes, a list should be maintained of potential ARARs as they are identified for a site. As the RI/FS progresses, each ARAR will need to be defined. The assistance of the appropriate support agency should be sought in identifying support agency ARARs and confirming their applicability or relevance and appropriateness.

2.2.6 Identify Data Needs

The identification of data needs is the most important part of the scoping process. Data needs are identified by evaluating the existing data and determining what additional data are necessary to characterize the site, develop a better conceptual understanding of the site, better define the ARARs, narrow the range of remedial alternatives that have been identified, and support enforcement activities.

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[6] In addition, compliance with certain environmental statutes (e.g., the National Historic Preservation Act) is simplified by early consultation with the responsible Federal agency.

The need for additional site data is evaluated relative to meeting the site-specific RI/FS objectives. In general, the RI/FS must obtain data to define source areas of contamination, the potential pathways of migration, and the potential receptors and associated exposure pathways to the extent necessary to:

- Determine whether, or to what extent, a threat to human health or the environment exists
- Develop and evaluate remedial alternatives (including the no-action alternative)
- Support future enforcement or cost-recovery activities

If additional data are needed, the intended uses of the data are identified, strategies for sampling and analyses are developed, DQOs are established, and priorities are assigned according to the importance of the data in meeting the objectives of the RI/FS.

The possible uses of the data include the following:

- Monitoring during implementation
- Health and safety planning
- Site characterization
- Risk assessment
- Evaluating alternatives
- Determining the PRP
- Engineering the design of alternatives

A more complete description of the data uses and their appropriate analytical levels (Figure 2-3) can be found in the *DQO Guidance*.

Setting priorities for data use helps to determine the highest level of confidence required for each type of data. For example, additional data on soil contamination may be necessary for all the uses listed above but may be of highest priority for risk assessment and evaluation alternatives. Within these two use categories, the evaluation of alternatives may require a much greater level of confidence in the contaminant types and concentrations on site so that cost estimates for treatment can be prepared to meet or approach the goal of a +50 percent/-30 percent accuracy level. As a result, data needs specifying the level of allowable uncertainty would be set for the evaluation of alternatives use category and would therefore provide an acceptable level of confidence for the remaining data uses.

Sensitivity analyses may be useful in evaluating the acceptable level of uncertainty in data. Critical parameters in any of the use categories can be varied over a probable range of values that were identified in the conceptual site model and that determine the effect on meeting the RI/FS objectives. For example, preliminary treatment costs for contaminated soil can be calculated for various contaminant types and volumes. The sensitivity that contaminant volume and type has on treatment cost can be assessed so that sufficient site characterization data are collected to allow costing of treatment alternatives during the FS using a goal of +50 percent/-30 percent cost accuracy.

In the development of data requirements, time and resource constraints must be balanced with the desired confidence level of the data. The turnaround time necessary for certain analytical procedures may, in some cases, preclude achieving the original level of confidence desired.

Likewise, resource constraints such as the availability of a laboratory, sampling and analysis equipment, and personnel may also influence the determination of data requirements. Because of the high cost of sampling and analysis for contaminants on the hazardous substances list, data acquisition should be focused only on the data quality and quantity necessary and sufficient to meet the RI/FS objectives. It is also important to do any necessary logistical planning once data needs are identified. For example, if it will be necessary to acquire aerial photographs to adequately evaluate a site, it should be noted early in the process so that the acquisition can begin early.

2.2.7 Design a Data Collection Program

Once the level of confidence required for the data is established, strategies for sampling and analysis can be developed. The identification of sampling requirements involves specifying the sampling design; the sampling method; sample numbers, types, and locations; and the level of sampling quality control. Data may be collected in multiple sampling efforts to use resources efficiently, and the level of accuracy may increase as the focus of sampling is narrowed. The determination of analytical requirements involves specifying the most cost-effective analytical method that, together with the sampling methods, will meet the overall data needs for the RI/FS. Data quality requirements specified for sampling and analysis include precision, accuracy, representativeness, completeness, and comparability.

A description of the methods to be used in analyzing data obtained during the RI should be included in a SAP. The level of detail possible in defining the data evaluation tasks will depend on the quality of the site conceptual model. If the site is well understood, data evaluation techniques should be specified and

DATA USES	ANALYTICAL LEVEL	TYPE OF ANALYSIS
Site Characterization Monitoring During Implementation	LEVEL I	• Total Organic/Inorganic Vapor Detection Using Portable Instruments • Field Test Kits
Site Characterization Evaluation of Alternatives Engineering Design Monitoring During Implementation	LEVEL II	• Variety of Organics by GC; Inorganics by AA; XRF • Tentative ID; Analyte-Specific • Detection Limits Vary from Low ppm to Low ppb
Risk Assessment PRP Determination Site Characterization Evaluation of Alternatives Engineering Design Monitoring During Implementation	LEVEL III	• Organics/Inorganics Using EPA Procedures other than CLP can be Analyte-Specific • RCRA Characteristic Tests
Risk Assessment PRP Determination Evaluation of Alternatives Engineering Design	LEVEL IV	• HSL Organics/Inorganics by GC/MS; AA; ICP • Low ppb Detection Limit
Risk Assessment PRP Determination	LEVEL V	• Non-Conventional Parameters • Method-Specific Detection Limits • Modification of Existing Methods • Appendix 8 Parameters

Figure 2-3. Summary of analytical levels appropriate to data uses.

described. This information is especially important if numerical modeling is anticipated. If little existing information is available, the task descriptions may be very general, since it may not be clear which data evaluation techniques will be appropriate. If information is lacking, descriptions of potential evaluation techniques could be included, and in addition to describing site characterization techniques, methods to be used in the risk assessment also should be described.

2.2.8 Develop a Work Plan

Tasks to be conducted during the RI/FS should be identified and documented in a work plan. Although this work plan will constitute the planning through the completion of the RI/FS, the level of detail with which specific tasks can be described during scoping will depend on the amount and quality of existing data. Therefore, in situations in which additional data are needed to adequately scope the development and evaluation of alternatives, emphasis should be placed on limiting the level of detail used to describe these subsequent tasks and simply noting that the scope of these activities will be refined later in the process. This will reduce the time needed to prepare and review the initial work plan. As the RI/FS process progresses and a better understanding of the site is gained, these task descriptions can be refined. The preliminary descriptions of tasks needed to complete the RI/FS should be documented in the work plan and can be used as a basis for scheduling and estimating the RI/FS budget.

2.2.9 Identify Health and Safety Protocols

Protecting the health and safety of the investigative team and the general public is a major concern during remedial response actions. Workers may be exposed to a variety of hazards including toxic chemicals, biological agents, radioactive materials, heat or other physical stresses, equipment-related accidents, and fires or explosions. The surrounding community may be at increased risk from unanticipated chemical releases, fires, or explosions created by onsite activities. In recognition of these concerns, OSHA has published regulations that stress the importance both of an underlying health and safety program and of site-specific safety planning. The following is a list of documents that contain regulations pertaining to workers at hazardous waste sites:

- *American National Standards, Practices for Respiratory Protection* (American National Standards Institute, 1980)
- *Guidance Manual for Superfund Activities*, Volumes 1-9 (National Institute for Occupational Safety and Health, 1985)
- *Occupational Health Guidelines for Chemical Hazards* (National Institute for Occupational Safety and Health, 1981)
- *Safety Manual for Hazardous Waste Site Investigations* (U. S. EPA, 1979)
- *Interim Standard Operating Safety Guides* (U.S. EPA, 1982)
- *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities* (NIOSH/OSHA/USCC/USEPA, 1985)
- *NIOSH/OSHA Pocket Guide to Chemical Hazards* (National Institute for Occupational Safety and Health, 1978)
- *National Fire Codes* (National Fire Protection Association, 1981)

2.2.10 Conduct Community Interviews

The community relations staff members, which can be either lead agency or contractor personnel and technical staff, should work together during the scoping process so that there is sufficient information to conduct community interviews. Community relations staff members then meet with the identified groups or individuals to gain an understanding of the site's history and the community's involvement with the site from the community's perspective. The lead agency will determine on a site-specific basis the type and number of interviews that need to be conducted to obtain sufficient information to develop an effective community relations plan. The results of the interviews should be made available to all technical staff members to assist in identifying potential waste types and disposal practices, potential pathways of contamination, and potential receptors. On the basis of an understanding of the issues and concerns of the community, the community relations history, and the citizens' indicated preferences for how they would like to be informed concerning site activities, the community relations plan is prepared. Plans should provide opportunities for public input throughout the remedial planning process as appropriate.

2.3 Deliverables and Communication

There are several points during the scoping process when communication is required between the lead agency and its contractor and/or the support agency (see Table 2-2). It is especially important that discussion and information exchange occur if interim actions or limited field investigations are considered necessary. For all RI/FSs, it is desirable for the lead and support agencies and their contractors to review existing data and to agree on the major tasks to be conducted at a site. Specific guidance for the timing and nature of communications between the lead and support agencies is provided in the "Superfund Memorandum of Agreement Guidance" (in preparation).

Deliverables required for all RI/FSs in which field investigations are planned consist of a work plan, an SAP, a health and safety plan (HSP), and a community relations plan (CRP). Although these plans usually are submitted together, each plan may be delivered separately. Each of these plans is described below.

2.3.1 *Work Plan*

2.3.1.1 Purpose

The work plan documents the decision and evaluation made during the scoping process and presents anticipated future tasks. It also serves as a valuable tool for assigning responsibilities and setting the project's schedule and cost. Information on planning work for lead agency staff may be found in the *Superfund Federal-Lead Remedial Project Management Handbook* (U.S. EPA, December 1986); and the *Superfund State-Lead Remedial Project Management Handbook* (U.S. EPA, December 1986). The primary user of the RI/FS work plan is the lead agency for the site (usually either the EPA Region or the appropriate federal or state agency) and the project team that will execute the work. Secondary users of the work plan include other groups or agencies serving in a review capacity, such as EPA Headquarters and local government agencies. The work plan is usually made available for public comment (often in conjunction with a public meeting) and is placed in the Administrative Record.

2.3.1.2 Preparation

The work plan presents the initial evaluation of existing data and background information performed during the scoping process, including the following:

- An analysis and summary of the site background and the physical setting
- An analysis and summary of previous responses
- Presentation of the conceptual site model, including an analysis and summary of the nature and extent of contamination; preliminary assessment of human health and environmental impacts; and the additional data needed to conduct the baseline risk assessment
- Preliminary identification of general response actions and alternatives and the data needed for the evaluation of alternatives

The work plan also defines the scope and objectives of RI/FS activities to the extent possible. The scope of the RI site characterization should be documented in the work plan, with detailed descriptions provided in the SAP. Later tasks will usually be scoped in less detail, pending the acquisition of more complete data about the site.

The initial work plan is prepared prior to the RI site characterization.[7] Because the RI/FS process is dynamic and iterative, the work plan or supplemental plans, such as the QAPP and the FSP, can be modified during the RI/FS process to incorporate new information and refined project objectives. The work plan should be revised, if necessary, before (1) additional iterations of site characterization activities, and (2) treatability investigations. On federal-lead sites, a work plan revision request (WPRR) is submitted for approval of any significant changes to the budget schedule, or scope. EPA has found technical directive memorandums (TDMs) to be useful for decreasing administrative time when the proposed work plan changes do not affect the total budget or schedule.

2.3.1.3 Work Plan Elements

Five elements (Introduction, Site Background and Physical Setting, Initial Evaluation, Work Plan Rationale, and RI/FS Tasks) typically are included in a work plan. These elements are described in Appendix B.

Among the elements to be included is the specification of RI/FS tasks. For federal-lead sites, 14 standard tasks have been defined to provide consistent reporting and allow more effective monitoring of RI/FS projects. Figure 2-4 shows these tasks and their relationship to the phases of an RI/FS, and detailed task definitions are included in Appendix B. Although RI/FSs that are not federal-lead projects are not required to use these standard tasks, their use provides a valuable project management tool that allows for compilation of historical cost and schedule data to help estimate these tasks during project planning and management.

Project Management Considerations. Project management considerations may be specified in the work plan to define relationships and responsibilities for selected task and project management items. This specification is particularly useful when the lead agency is using extensive contractor assistance. The following project management considerations may be discussed in the work plan:

- Identification of staff (the lead agency's RPM, the PRP's project manager, the contractor, the contractor's site manager, and other team members)
- Coordination among the lead agency, the support agency, the PRPs and the contractors performing the work
- Coordination with other agencies (Typically, the lead agency's RPM is the focus for the coordination of all other agency and private participation in site activities and decisions.)

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[7] In enforcement cases, PRPs are typically responsible for the development of the work plan (See Appendix A).

Table 2-2. Communication and Deliverables During Scoping

Information Needed	Purpose	Potential Methods of Information Exchange
Interim actions (if necessary)	For lead agency and contractor to identify actions that will abate immediate threat to public health or prevent further degradation of the environment; to obtain concurrence of support agency	Meeting Tech Memo Other
Limited field investigations (if necessary)	For lead agency and contractor to improve focus of RI and reduce time and cost; to obtain concurrence of support agency	Meeting Tech Memo Other
Summary of existing data; field studies conducted prior to FS; identification of preliminary remedial action alternatives	For lead agency and contractor to confirm need for field studies; for lead agency and contractor to plan data collection; to obtain support agency review and concurrence	Meeting Tech Memo Other
Documentation of quality assurance (QA) and field sampling procedures	For contractor to obtain lead agency review and approval; for lead agency to obtain support agency review and comment	SAP (FSP,QAPP)
Documentation of health and safety procedures	For contractor to obtain lead agency agreement that OSHA safety requirements are met	Health and safety plan
Documentation of all RI/FS tasks	For contractor to obtain lead agency review and approval; for lead agency to obtain support agency concurrence	Work plan

- Coordination of subcontractors, if any, and description of health and safety requirements and responsibilities
- Interface for federal-lead projects with the Contract Laboratory Program (CLP), if needed, to minimize sampling requirements by use of field screening, to schedule analyses well ahead of sampling trips, and to accurately complete CLP paperwork
- Cost control (including a description of procedures for contractors to report expenditures)
- Schedule control (including a description of schedule tracking methods and procedures for contractors to report activities to the lead agency)
- Identification of potential problems so that the RPM and site manager can develop contingency plans for resolution of problems during the RI/FS
- Evidentiary considerations, if needed, to ensure that project staff members are trained with regard to requirements for admissibility of the work in court

Cost and Key Assumptions. For federal-lead sites, the RI/FS work plan includes a detailed summary of projected labor and expense costs,[8] broken down by the 14 tasks listed in Figure 2-3 and described in Appendix B, and a description of the key assumptions required to make such a cost estimate. During scoping, more detailed costs typically are provided for the RI site characterization tasks than for later phases of the RI/FS. The less-detailed costs may be refined as field investigations progress and the nature and extent of site contamination is more fully understood.

RI/FS costs vary greatly among sites and are influenced by the following:

- The adequacy of existing data
- The size and complexity of the site
- The level of personnel protection required for onsite workers
- The number and depth of wells required and the types of subsurface conditions where wells will be installed
- The number and types of media sampled
- The number of samples required for each medium
- The need for support of enforcement activities
- The need for bench- or pilot-scale tests

Schedule. The anticipated schedule for the RI/FS is formulated on the basis of the scope of the project, including the identification of key activities and deliverable dates. As with cost, the scheduling of tasks varies among sites.

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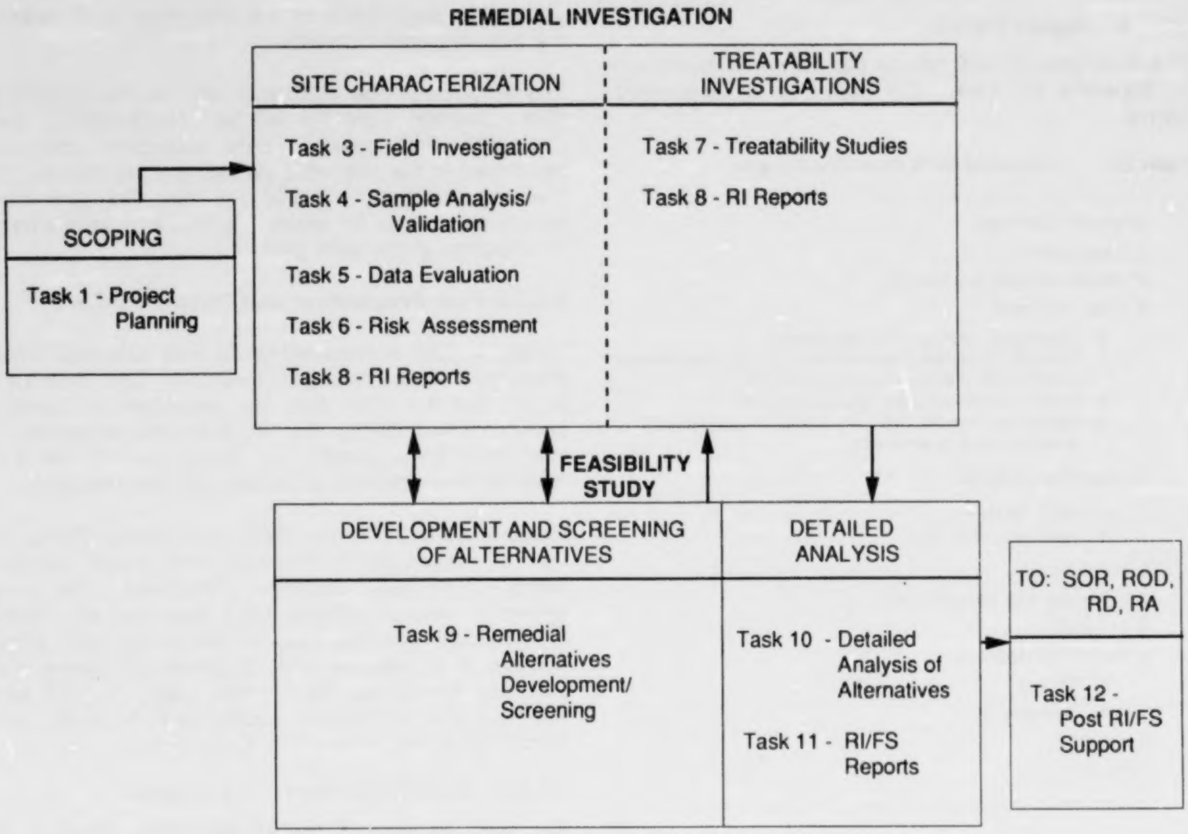
[8] The estimated RI/FS costs prepared by the RPM during the scoping process will form the basis for evaluating costs proposed by the contractor in the work plan and should help facilitate the control of project costs as the RI/FS proceeds. Cost estimates may not be required for State- and PRP-lead RI/FSs.


REMEDIAL INVESTIGATION
SITE CHARACTERIZATION
TREATABILITY INVESTIGATIONS
Task 3 - Field Investigation
Task 4 - Sample Analysis/ Validation
Task 5 - Data Evaluation
Task 6 - Risk Assessment
Task 8 - RI Reports
Task 7 - Treatability Studies
Task 8 - RI Reports
SCOPING
Task 1 - Project Planning
FEASIBILITY STUDY
DEVELOPMENT AND SCREENING OF ALTERNATIVES
DETAILED ANALYSIS
Task 9 - Remedial Alternatives Development/ Screening
Task 10 - Detailed Analysis of Alternatives
Task 11 - RI/FS Reports
TO: SOR, ROD, RD, RA
Task 12 - Post RI/FS Support

RI/FS WORK PLAN STANDARD TASKS

TASK	TITLE
1	Project Planning
2	Community Relations *
3	Field Investigation
4	Sample Analysis/ Validation
5	Data Evaluation
6	Risk Assessment
7	Treatability Study/ Pilot Testing
8	Remedial Investigation Reports
9	Remedial Alternatives Development/ Screening
10	Detailed Analysis of Alternatives
11	Feasibility Study (RI/FS) Reports
12	Post RI/FS Support
13	Enforcement Support *
14	Miscellaneous Support *

* Tasks that can occur in any Phase of the RI/FS

Figure 2-4. Relationship of RI/FS Tasks to Phased RI/FS Approach.

2.3.1.4 Report Format

The work plan should include the elements described in Appendix B. Table 2-3 provides a suggested format.

Table 2-3. Suggested RI/FS Work Plan Format

Executive Summary
1. Introduction
2. Site Background and Setting
3. Initial Evaluation
    - Types and volumes of waste present
    - Potential pathways of contaminant migration/preliminary public health and environmental impacts
    - Preliminary identification of operable units
    - Preliminary identification of response objectives and remedial action alternatives
4. Work Plan Rationale
    - DQO needs
    - Work plan approach
5. RI/FS Tasks
6. Costs and Key Assumptions
7. Schedule
8. Project Management
    - Staffing
    - Coordination
9. References

Appendices

2.3.2 Sampling and Analysis Plan (SAP)

2.3.2.1 Purpose

The SAP consists of two parts: (1) a quality assurance project plan (QAPP) that describes the policy, organization, functional activities, and quality assurance and quality control protocols necessary to achieve DQOs dictated by the intended use of the data; and (2) the field sampling plan (FSP) that provides guidance for all fieldwork by defining in detail the sampling and data-gathering methods to be used on a project. The FSP should be written so that a field sampling team unfamiliar with the site would be able to gather the samples and field information required. Guidance for the selection and definition of field methods, sampling procedures, and custody can be acquired from the *Compendium of Superfund Field Operations Methods*, which is a compilation of demonstrated field techniques that have been used during remedial response activities at hazardous waste sites (U.S. EPA, September 1987, hereafter referred to as the *Compendium*). To the extent possible, procedures from this *Compendium* should be incorporated by reference. In addition, the FSP and QAPP should be submitted as a single document (although they may be bound separately to facilitate use of the FSP in the field). These efforts will streamline preparation of the document and reduce the time required for review.

The purpose of the SAP is to ensure that sampling data collection activities will be comparable to and compatible with previous data collection activities performed at the site while providing a mechanism for planning and approving field activities. The plan also serves as a basis for estimating costs of field efforts for inclusion in the work plan.

2.3.2.2 Plan Preparation and Responsibilities

Timing. A SAP is prepared for all field activities. Initial preparation takes place before any field activities begin, but the SAP may be amended or revised several times during the RI site characterization, treatability investigations, or during the FS as the need for field activities is reassessed and rescoped.

Preparation and Review. EPA, the states, PRPs, or the contractors conducting the work should prepare SAPs for all field activities performed. The lead agency's project officer must approve the SAP. Signatures on the title page of the plan usually show completion of reviews and approvals. Environmental sampling should not be initiated until the SAP has received the necessary approvals.[9] A suggested format for a SAP is listed in Table 2-4.

2.3.2.3 Field Sampling Plan Elements

The FSP consists of the six elements contained in Table 2-4. These elements are described more fully in Appendix B.

2.3.2.4 Quality Assurance Project Plan Elements

The QAPP should contain 14 elements. These elements are listed in Table 2-4 and described in Appendix B. The required information for each of the elements of a QAPP need not be generated each time a QAPP is prepared. Only those aspects of a QAPP that are specific to the site being investigated need to be explicitly described. If site-specific information is already contained in another document (e.g., the FSP) it need only be referenced. Similarly, any information contained in guidance documents such as the *DQO Guidance* should only be referenced and not repeated in the QAPP.

2.3.3 Health and Safety Plan

2.3.3.1 Purpose

Each remedial response plan will vary as to degree of planning, special training, supervision, and protective equipment needed. The health and safety plan

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[9] Approval to conduct limited sampling (see Section 2.2.2.3) may be given as part of the interim authorization to prepare the work plans.

Table 2-4. Suggested Format for SAP (FSP and QAPP)

FSP

1. Site Background
2. Sampling Objectives
3. Sample Location and Frequency
4. Sample Designation
5. Sampling Equipment and Procedures
6. Sample Handling and Analysis

QAPP

Title Page
Table of Contents

1. Project Description
2. Project Organization and Responsibilities
3. QA Objectives for Measurement
4. Sampling Procedures
5. Sample Custody
6. Calibration Procedures
7. Analytical Procedures
8. Data Reduction, Validation, and Reporting
9. Internal Quality Control
10. Performance and Systems Audits
11. Preventative Maintenance
12. Data Assessment Procedures
13. Corrective Actions
14. Quality Assurance Reports

prepared to support the field effort must conform to the firm's or agency's health and safety program which must be in compliance with OSHA.

The site health and safety plan should be prepared concurrently with the SAP to identify potential problems early, such as the availability of adequately trained personnel and equipment. OSHA requires that the plan include maps and a detailed site description, results of previous sampling activities, and field reports. The plan preparer should review site information, along with proposed activities, and use professional judgment to identify potentially hazardous operations and exposures and prescribe appropriate protective measures. Appendix B of the *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities* (NIOSH/OSHA/USCG/USEPA, 1985) provides an example of a generic format for a site health and safety plan that could be tailored to the needs of a specific employer or site.

2.3.3.2 Elements of the Health and Safety Plan

Each site health and safety plan should include, at a minimum, the 11 elements described in Appendix B of this guidance. The specific information required in a site health and safety plan is listed in 29 CFR 1910.120.

2.3.3.3 Site Briefings and Inspections

The OSHA regulation requires that safety briefings be held "prior to initiating any site activity and at such other times as necessary to ensure that employees are apprised of the site safety plan and that it is being followed."

The final component of site health and safety planning or informational programs is site auditing to evaluate compliance with and effectiveness of the site health and safety plan. The site health and safety officer or that person's designee should carry out the inspections.

2.3.4 Community Relations Plan

2.3.4.1 Purpose

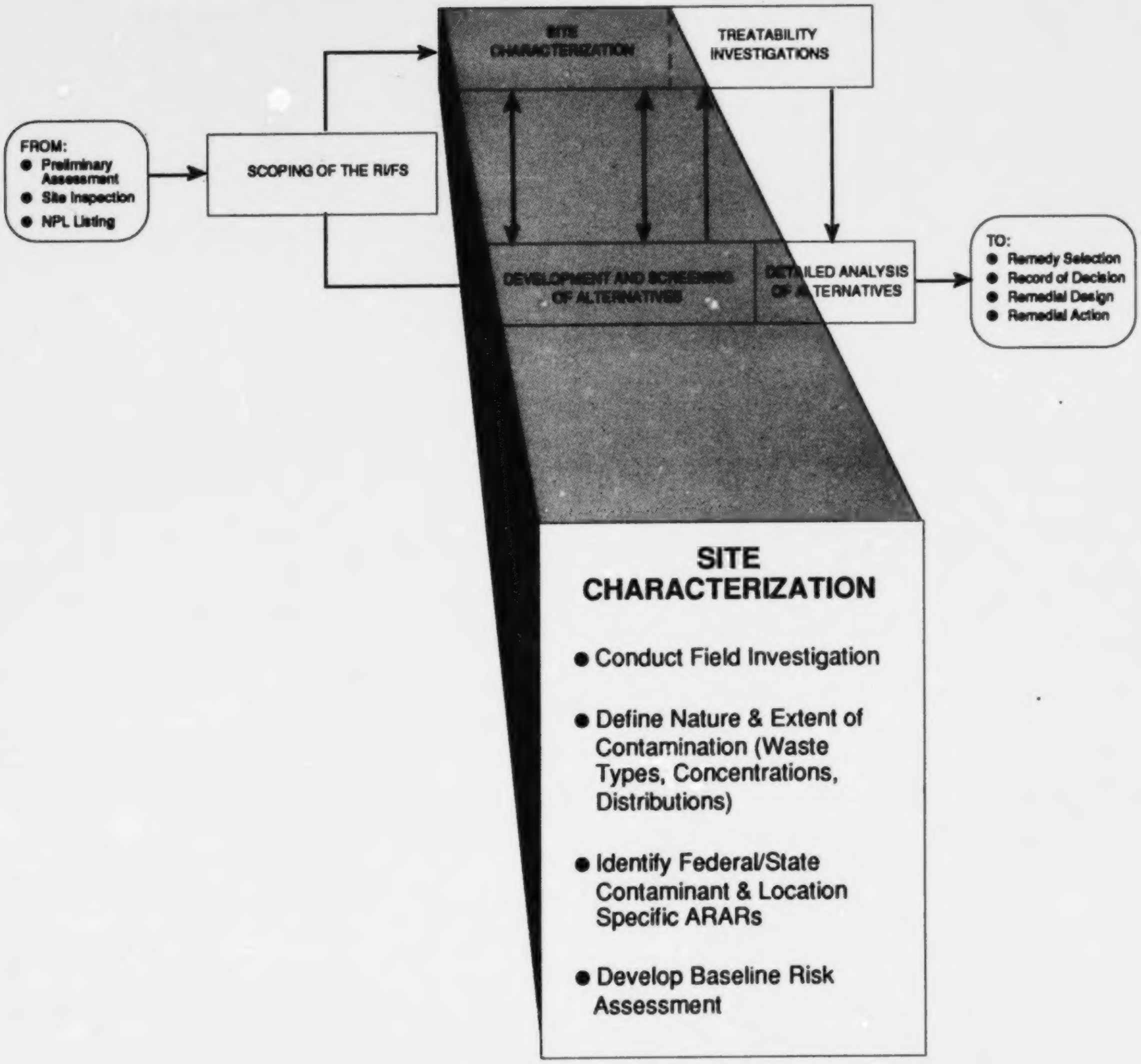
The CRP documents the community relations history and the issues of community concern. It should describe the techniques that will be needed to achieve the objectives of the program. The plan is used by community relations staff, but it should also be used by federal and state agency technical staff members when planning technical work at the site.

2.3.4.2 Community Relations Plan Elements

Report preparation methods, the elements contained in a CRP, and a recommended format are included in *Community Relations in Superfund: A Handbook* (U.S. EPA, Interim, June 1988). This handbook also includes useful examples of community relations plans.

CHAPTER 3

SITE CHARACTERIZATION


FROM:
Preliminary Assessment
Site Inspection
NPL Listing
SCOPING OF THE RI/FS
SITE CHARACTERIZATION
TREATABILITY INVESTIGATIONS
DEVELOPMENT AND SCREENING OF ALTERNATIVES
DETAILED ANALYSIS OF ALTERNATIVES
TO:
Remedy Selection
Record of Decision
Remedial Design
Remedial Action
SITE CHARACTERIZATION
Conduct Field Investigation
Define Nature & Extent of Contamination (Waste Types, Concentrations, Distributions)
Identify Federal/State Contaminant & Location Specific ARARs
Develop Baseline Risk Assessment

Chapter 3

Site Characterization

3.1 Introduction

During site characterization, the sampling and analysis plan (SAP), developed during project planning, is implemented and field data are collected and analyzed to determine to what extent a site poses a threat to human health or the environment. The major components of site characterization are presented in Figure 3-1 and include:

- Conducting field investigations as appropriate
- Analyzing field samples in the laboratory
- Evaluating results of data analysis to characterize the site and develop a baseline risk assessment
- Determining if data are sufficient for developing and evaluating potential remedial alternatives

Because information on a site can be limited prior to conducting an RI, it may be desirable to conduct two or more iterative field investigations so that sampling efforts can be better focused. Therefore, rescoping may occur at several points in the RI/FS process. During site characterization, rescoping and additional sampling may occur if the results of field screening or laboratory analyses show that site conditions are significantly different than originally believed. In addition, once the analytical results of samples have been received (either from a laboratory or a mobile lab) and the data evaluated, it must be decided whether further sampling is needed to assess site risks and support the evaluation of potential remedial alternatives in the FS. At this time, it is usually apparent whether the data needs identified during project planning were adequate and whether those needs were satisfied by the first round of field sampling. As discussed in Chapter 4, there are also points during the FS when the need for additional field studies may be identified. These additional studies, if needed, can be conducted during subsequent site characterization activities.

This chapter provides detailed descriptions of those activities that may be required during the RI site characterization. As discussed earlier, the complexity and extent of potential risks posed by Superfund sites is highly variable. Therefore, the lead and support agencies will have to decide on a site-specific basis which of the activities described in this chapter must be conducted to adequately characterize the problem(s) and help in the evaluation of remedial alternatives.

3.2 Field Investigation Methods

Field investigation methods used in RIs are selected to meet the data needs established in the scoping process and outlined in the work plan and SAP. This section provides an overview of the type of site characterization data that may be required and the investigative methods used in obtaining these data. The following sections describe methods for (1) implementing field activities, (2) investigating site physical characteristics, (3) defining the sources of contamination, and (4) evaluating the nature and extent of contamination. Specific information on the field investigation methods described below is contained in the *Compendium*. Sections of the *Compendium* that apply to particular types of field investigations are shown in Table 3-1.

3.2.1 *Implement Field Activities*

In addition to developing the SAP, fieldwork support activities, such as the following, are often necessary before beginning fieldwork:

- Assure that access to the site and any other areas to be investigated has been obtained
- Procure subcontractors such as drillers, excavators, surveyors, and geophysicists
- Procure equipment (personal protective ensembles, air monitoring devices, sampling equipment, decontamination apparatus) and supplies (disposables, tape, notebook, etc.)
- Coordinate with analytical laboratories, including sample scheduling, sample bottle acquisition reporting, chain-of-custody records, and procurement of close support laboratories or other in-field analytical capabilities
- Procure onsite facilities for office and laboratory space, decontamination equipment, and vehicle

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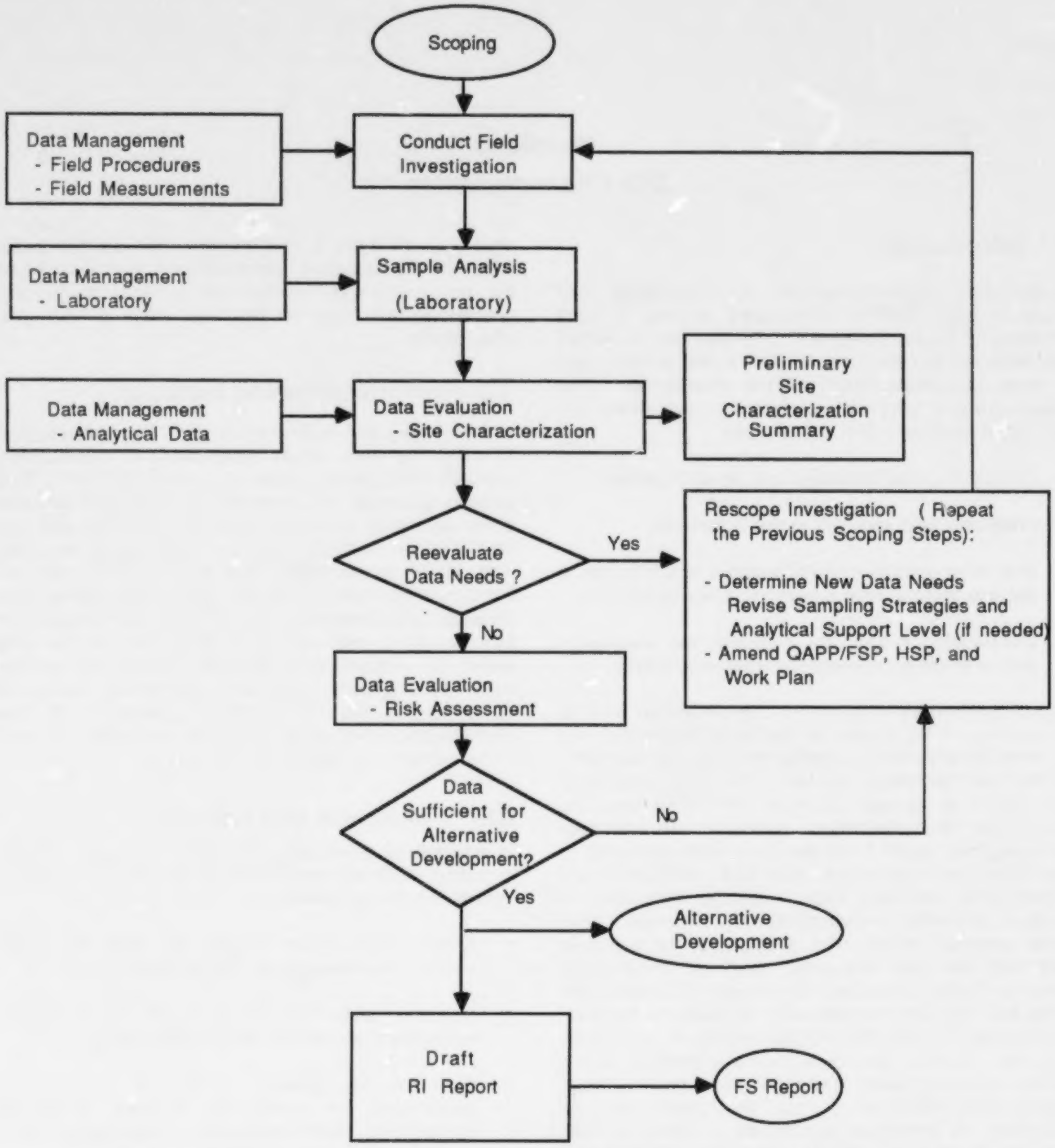
Scoping
Conduct Field Investigation
Data Management - Field Procedures - Field Measurements
Data Management - Laboratory
Sample Analysis (Laboratory)
Data Management - Analytical Data
Data Evaluation - Site Characterization
Preliminary Site Characterization Summary
Reevaluate Data Needs ?
Yes
No
Rescope Investigation (Repeat the Previous Scoping Steps):
- Determine New Data Needs Revise Sampling Strategies and Analytical Support Level (if needed)
- Amend QAPP/FSP, HSP, and Work Plan
Data Evaluation - Risk Assessment
Data Sufficient for Alternative Development?
No
Yes
Alternative Development
Draft RI Report
FS Report

Figure 3-1. Major components of site characterization.

maintenance and repair, and sample storage, as well as onsite water, electric, telephone, and sanitary utilities

- Provide for storage or disposal of contaminated material (e.g., decontamination solutions, disposable equipment, drilling muds and cuttings,

Table 3-1. Relationship Among Site Characterization Tasks and the *Compendium*

Tasks	Applicable Sections and Subsections of the *Compendium of Superfund Field Operations Methods*
Field Investigation	
Air	7, 11, 15
Biota[1]	12
Close support laboratories	5.2, 7, 15
RI-derived waste disposal	3.2, 5.2.6.4, 8.1.6.3
Soil gas	
Support	3, 17, 18, 19, 20
Well logging	8.1, 8.3
Mapping and survey	14
Geophysical	8.4
Well installation	8.1, 8.5
Ground water	8.5
Soil	8.1, 8.2, 8.3
Source testing	7, 13, 15
Surface water	10
Sample analysis	
Fieldwork, close support laboratory	5.2, 15
Data validations	16
Sample management	4, 5, 6
Data evaluation	16

[1] OSWER is currently developing a Superfund environmental evaluation manual that will provide guidance for conducting ecological investigations.

well-development fluids, well-purging water, and spill-contaminated materials)

Since procurement activities can take up to several months, they should be initiated as early as possible so as not to affect the overall RI/FS schedule. Schedule impacts should also be avoided by structuring contracts, where possible, such that there is no need to reprocure services for subsequent site characterization activities. This may be accomplished using contract options that are exercised only in the event that additional services or facilities are required (e.g., basic ordering agreements for well drilling).

Mobile labs or labs located near the site can often reduce the time necessary for completing RI activities. If such quick-turnaround analysis is available, it can be used to determine the location and type of subsequent sampling that must take place to more completely characterize the site. This may also alleviate the need to reprocure subcontractors, and significantly accelerate the completion of the RI. If such analytical techniques are to be employed, the work plan and SAP should allow for decisions on subsequent activities to be made in the field with oral approval from key management personnel.

3.2.2 Investigate Site Physical Characteristics

Data on the physical characteristics of the site and surrounding areas should be collected to the extent necessary to define potential transport pathways and receptor populations and to provide sufficient engineering data for development and screening of remedial action alternatives. Information normally needed can be categorized as surface features (including natural and artificial features), geology, soils, surface water hydrology, hydrogeology, meteorology, human populations, land use(s) and ecology.

3.2.2.1 Surface Features

Surface features may include facility dimensions and locations (buildings, tanks, piping, etc.), surface disposal areas, fencing, property lines and utility lines, roadways and railways, drainage ditches, leachate springs, surface-water bodies, vegetation, topography, residences, and commercial buildings. Features such as these are usually identified for possible contaminant migration and the location of potentially affected receptors. Investigation of surface features should not be limited to those that are onsite, but should include significant offsite features as well. Other facilities in the area that are potential contributors to contamination should also be identified.

A history of surface features at the site can be developed from existing data. As discussed in Chapter 2, the data may include historical photographs, past topographic surveys, operational records, and information obtained during interviews with owners, operators, local residents, and local regulatory agencies. Review of historical photographs is sometimes the most valuable of these methods. Aerial photographs are often available from such sources as the Environmental Monitoring Support Laboratory, Las Vegas (EMSL-LV), the Environmental Photographic Interpretation Center (EPIC), and the Soil Conservation Service of the U.S. Department of Agriculture.

Existing surface features may be described using aerial photography, surveying and mapping, and site inspection. Inspection of the site and the surrounding areas is normally augmented with photographs. Section 14 of the *Compendium* presents additional details on land surveying, aerial photography, and mapping.

3.2.2.2 Geology

Geology may control or affect the following aspects of a site:

- The depths, locations, and extents of water-bearing units or aquifers
- The release of contaminants and their subsequent movement
- The engineering geologic aspects of site exploration and remediation

The investigation of site geology should be tailored to ensure the identification of those features that will affect the fate and transport of contaminants. For example, an understanding of site geology is less important at a site at which release of contaminants occurs by volatilization to the atmosphere than at a site at which contaminants are moving toward the water table.

To understand the geology of a site, one must determine the geology of bedrock and of unconsolidated overburden and soil deposits. Table 3-2 summarizes specific information on overburden and bedrock geology that may be needed. The degrees to which overburden and bedrock geology must be understood depend on the geologic character of the site area, as well as the physical characteristics of the site itself. An understanding of regional geologic characteristics is useful in determining which aspect of site geology may have the greatest influence on the fate and transport of contaminants and the use of potential remedial technologies.

In general, an investigation of site geology should include the following steps:

- Determination of regional geology from available information
- Reconnaissance mapping of the area, which may include geophysical investigations onsite
- Subsurface explorations

The degree to which these steps are undertaken will be determined by the degree to which the need to evaluate geologic aspects of the site dictates the investigations needed in the RI/FS. These investigation methods are described in detail in Section 8 of the *Compendium* and summarized in Table 3-2.

3.2.2.3 Soils and the Vadose Zone

Properties of surface soils and the vadose zone influence the type and rate of contaminant movement to the subsurface and subsequently to the water table. Contaminants that can move through the surface soil and into the vadose zone may move directly to the water table or they may be partially or fully retained within the vadose zone to act as continual sources of ground-water contamination. Engineering, physical, and chemical properties of soil and vadose zone materials can be measured in the field or in the laboratory. Table 3-3 summarizes typical methods for soil and vadose zone investigations.

3.2.2.4 Surface-Water Hydrology

Surface-water features may include erosion patterns and surface-water bodies such as ditches, streams, ponds, and lakes. The transport of contaminants in surface-water bodies is largely controlled by flow, which in streams is a function of the gradient, geometry, and coefficient of friction. A description of how flow is measured can be found in Section 10 of the *Compendium*. Contaminants have three possible modes of transport: (1) sorption onto the sediment carried by the flow, (2) transport as suspended solid, and (3) transport as a solute (dissolved). The transport of dissolved contaminants, which move the fastest, can be determined by characterizing the flow of the surface water and the contaminant dispersion. Sediment and suspended solid transport involve other processes such as deposition and resuspension. Table 3-4 presents the surface-water information that may be required for characterizing sites.

If potential pathways include surface water, necessary data about impoundments may include (1) physical dimensions such as depth, area, and volume; (2) residence time; and (3) current direction and rates. As with impoundments, the direction and velocity of lake currents are often highly variable and, as a result, are difficult to measure and accurately predict. Site mapping will provide much of this information. Measurement techniques (which are specified in Section 10, Surface Hydrology, of the *Compendium*) include the use of current meters and drogue tracking.

3.2.2.5 Hydrogeology

Determination of site hydrogeology involves identifying geologic characteristics, hydraulic properties, and ground-water use, as defined in Tables 3-5 and 3-6 and described in Section 8 of the *Compendium*. The determination of site geology and hydrogeology can often be incorporated into a single investigative program. Regional hydrogeologic conditions can be determined from existing information; site-specific hydrogeologic conditions can be determined using subsurface explorations, well installations, and field testing of hydraulic properties. Table 3-7 summarizes the typical data

Table 3-2. Summary of Site Geology Information

Information Needed	Purpose of Rationale	Collection Methods
• Geology of unconsolidated overburden and soil deposits - Thickness and areal extent of units - Lithology; mineralogy - Particle size and sorting; porosity • Geology of bedrock - Type of bedrock (igneous, metamorphic, sedimentary) - Lithology; petrology - Structure (folds, faults) - Discontinuities (joints, fractures, bedding plants, foliation) - Unusual features such as igneous intrusive bodies (dikes), lava tubes, solution cavities in limestone (karst)	For both unconsolidated and bedrock geology: • Evaluate the influence of geology on water-bearing units and aquifers • Evaluate the influence of geology on release and movement of contaminants • Obtain information on the engineering geologic aspects of site remediation	For both unconsolidated and bedrock geology: • Determination of regional geology from available information - Published reports (geologic reports, ground-water reports, soil survey reports) - State geologic maps - USGS topographic quadrangle maps - Descriptions of regional geology from previous reports of site investigations • Site reconnaissance mapping - Field mapping of surficial soil and overburdewn units, bedrock outcrops, surface water drainage, springs, and seeps - Analyses of aerial photography or other remote imagery - Surface geophysics • Subsurface explorations - Test borings or core borings (with or without sampling) - Test pits and trenches - Description and logging of subsurface geologic materials - Sample collection for laboratory analyses of physical properties and mineral content - Borehole geophysics

collected and available analytical methodologies used during a hydrogeologic investigation.

3.2.2.6 Meteorology

Meteorological data are often required to characterize the atmospheric transport of contaminants for risk assessment determinations and provide real-time monitoring for health and safety issues. Representative offsite and site-specific data may be obtained using sampling methods outlined in Section 11, "Meteorology and Air Quality," of the *Compendium*. This publication also discusses data requirements for using refined air quality modeling and applicable models. Table 3-8 summarizes atmospheric investigations.

3.2.2.7 Human Populations and Land Use

Information should be collected to identify, enumerate, and characterize human populations potentially exposed to contaminants released from a site. For a potentially exposed population, information should be collected on population size and location. Special consideration may be given to identifying potentially sensitive subpopulations (e.g., pregnant women, infants) to better facilitate the characterization of risks posed by contaminants exhibiting specific effects (e.g., mutagens, teratogens). Census and other survey data may be used to identify and describe the population potentially exposed to contaminated media. Information may also be available from U.S. Geological Survey maps, land use plans, zoning maps, and regional planning authorities.

Data describing the type and extent of human contact with contaminated media also are needed,[1] including:

- Location and use of surface waters
  - Drinking water intakes and distribution
  - Recreational (swimming, fishing) areas
  - Connection between surface-water bodies
- Local use of ground water as a drinking-water source
  - Number and location of wells

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[1] In some situations, information may be available from the ATSDR if they previously have conducted health consultations.

Table 3-3. Summary of Soil and Vadose Zone Information

Information Needed	Purpose or Rationale	Collection Methods	
		Primary	Secondary
Soil Characteristics:			
Type, holding capacity, temperature, biological activity, engineering properties	Estimate the effect of the properties on infiltration and retardation of leachates and the release of gaseous contaminants	Reports and maps by Federal and county agencies, Soil Conservation Service (SCS) publications	Borehole sampling, laboratory measurements (ASTM methods), water budget methods, instantaneous rate method, seepage meters, infiltrometers, test basins
Soil Chemistry Characteristics:			
Solubility, ion speciation, adsorption coefficients, leachability, cation exchange capacity, mineral partition coefficients, chemical and sorptive properties	Predict contaminant movement through soils and availability of contaminants to biological systems	Existing scientific literature	Chemical analysis, column experiments, leaching tests
Vadose Zone Characteristics:			
Permeability, variability, porosity, moisture content, chemical characteristics, extent of contamination	o Estimate flux in the vadose zone	Existing literature	Water budget with soil moisture accounting Draining profile methods Measurement of hydraulic gradients Estimates assuming unit hydraulic gradient Flow meters Methods based on estimating or measuring hydraulic conductivity, using: o Laboratory parameters o Relationships between hydraulic conductivity and grain size o Catalog of hydraulic properties o Field measurements of hydraulic conductivity using single or multiple wells
	o Estimate velocity in the vadose zone	Existing literature	o Tracers o Calculations using flux values o Calculations using long-term infiltration data
	o Evaluate pollutant movement in the vadose zone	Existing literature	Four-probe electrical method Electrical conductivity probe Salinity sensors Solids sampling followed by laboratory extraction of pore water Solids sampling for organic and microbial constituents Suction Lysimeters Sampling perched ground water

Table 3-4. Summary of Surface-Water Information

Information Needed	Purpose or Rationale	Collection Methods	
		Primary	Secondary
Drainage Patterns:			
o Overland flow, topography, channel flow pattern, tributary relationships, soil erosions, and sediment transport and deposition	Determine if overland or channel flow can result in onsite or offsite flow and if patterns form contaminant pathways	Topographic maps, site inspection, and soil conservation services	Aerial mapping and ground survey
Surface-Water Bodies:			
o Flow, stream widths and depths, channel elevations, flooding tendencies, and physical dimensions of surface-water impoundments	Determine volume and velocity, transport times, dilution potential, and potential spread of contamination	Public agency data and atlases; catalogs, maps, and handbooks for background data	Aerial mapping and ground survey
o Structures	Effect of manmade structures on contaminant transport and migration	Public agency maps and records and ground survey	
o Surface-water/ground-water relationships	Predict contaminant pathways for interceptive remedial actions	Public agency reports and surveys	Water level measurements and modeling
Surface-Water Quality:			
o pH, temperature, total suspended solids, suspended sediment, salinity, and specific contaminant concentrations	Provide capacity of water to carry contaminants and water/sediment partitioning	Public agency computerized data files, handbooks, and open literature	Sampling and analysis

Table 3-5. Aspects of Site Hydrogeology

- Geologic aspects
  - Type of water-bearing unit or aquifer (overburden, bedrock)
  - Thickness, areal extent of water-bearing units and aquifers
  - Type of porosity (primary, such as intergranular pore space, or secondary, such as bedrock discontinuities or solution cavities)
  - Presence or absence of impermeable units or confining layers
  - Depths to water table; thickness of vadose zone
- Hydraulic aspects
  - Hydraulic properties of water-bearing unit or aquifer (hydraulic conductivity, transmissivity, storativity, porosity, dispersivity)
  - Pressure conditions (confined, unconfined, leaky confined)
  - Ground-water flow directions (hydraulic gradients, both horizontal and vertical), volumes (specific discharge), rate (average linear velocity)
  - Recharge and discharge areas
  - Ground-water or surface water interactions; areas of ground-water discharge to surface water
  - Seasonal variations of ground-water conditions
- Ground-water use aspects
  - Identify existing or potential aquifers
  - Determine existing near-site use of ground water

Table 3-6. Features of Ground-Water Systems

- Components of Ground-Water Systems
  - Unconfined aquifers
  - Confining beds
  - Confined aquifers
  - Presence and arrangement of components
- Water-bearing openings of the dominant aquifer
  - Primary openings
  - Secondary openings
- Storage and transmission characteristics of the dominant aquifer
  - Porosity
  - Transmissivity
- Recharge and discharge conditions of the dominant aquifer

- Human use or access to the site and adjacent areas
  - Residential
  - Commercial
  - Recreational use
- Location of population with respect to site
  - Proximity
  - Prevailing wind direction

Information on expected land use, as well as current land use, is desirable. Available population growth projections, land use plans, and zoning maps can help develop expected exposure scenarios. This information may be obtained from zoning boards, the census bureau, regional planning agencies, and other local governmental entities.

3.2.2.8 Ecological Investigations

Biological and ecological information collected for use in the baseline risk assessment aids in the evaluation of impacts to the environment and also helps to identify potential effects with regard to the implementation of remedial actions. The information should include a general identification of the flora and fauna associated in and around the site with particular emphasis placed on identifying sensitive environments, especially endangered species and their habitats and those species consumed by humans or found in human food chains. Examples of sensitive environments include wetlands, flood plains, wildlife breeding areas, wildlife refuges, and specially designated areas such as wild and scenic rivers or parks.

Depending on the specific circumstances, data may be needed for species that have key ecological functions in particular ecosystems, such as primary or secondary producers, decomposers, scavengers, predators, or species that occupy key positions in the food chains of humans or other species. Bioaccumulation data on food chain organisms, such as aquatic invertebrates and fish, may be particularly important to both environmental risk and human risk assessment.[2] Data gathered through biological assessment techniques (e.g., bioassays and/or field monitoring) may be useful in situations where there are complex mixtures, incomplete toxicity information, and/or unidentified or unmeasured compounds. The Natural Resources Trustees for the site should be contacted to determine if other ecological data are available that may be relevant to the investigation. A summary of environmental information that may be needed and potential collection methods is provided in Table 3-9.

Prudent judgment on the part of the site managers is required to ensure that only relevant data that will aid in evaluating potential ecological risk and/or potential remedial actions are collected. Because human health risks may be more substantial than ecological risks, and the mitigative actions taken to alleviate risks to human health are often sufficient to mitigate potential ecological risks as well, extensive ecological investigations may not be required for many sites.

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[2] Ecological information collected to aid in the assessment of risk to humans exposed through food chain contamination should be used in accordance with the *Superfund Public Health Evaluation Manual* (U.S. EPA, October 1986).

Table 3-7. Summary of Ground-Water Information

Information Needed	Purpose or Rationale	Collection Methods	
		Primary	Secondary*
Ground-Water Occurrence:			
• Aquifer boundaries and locations	Define flow limits and degree of aquifer confinement	Existing literature, water resource atlases	Installation of wells and piezometers (single level or multilevel)
• Aquifer ability to transmit water	Determine potential quantities and rates for treatment options	Pumping and injection tests of monitor wells	Ground-water level measurements (over time to monitor seasonal variations) Instrument survey of wells for calculation of ground-water elevations Borehole and surface geophysics
Ground-Water Movement:			
• Direction of flow	Identify most likely pathways of contaminant migration	Existing hydrologic literature	Water level measurements in monitor wells Testing of hydraulic properties using slug tests, tracer tests, and pump tests (short- or long-duration, single or multiple well) Elevation contours of water table or potentiometric surface Analytical calculations of flow directions and rates Computer generated simulations of ground-water flow and contaminant transport (using analytical or numerical methods) Generation of site water balance
• Rate of flow	Determine maximum potential migration rate and dispersion of contaminants	Existing hydrologic literature	Hydraulic gradient, permeability, and effective porosity from water level contours, pump test results, and laboratory analyses
Ground-Water Recharge/Discharge:			
• Location of recharge/discharge areas	Determine interception points for withdrawal options or areas of capping	Existing site data, hydrologic literature, site inspection	Comparsion of water levels in observation wells, piezometers, lakes, and streams Field mapping of ground-water recharge areas (losing streams, interstream areas) and ground-water discharge to surface water (gaining streams, seeps, and springs)
• Rate	Determine variability of loading to treatment options	Existing literature	Water-balance calculations aided by geology and soil data
Ground-Water Quality:			
• pH, total dissolved solids, salinity, specific contaminant concentrations	Determine exposure via ground water; define contaminant plume for evaluation of interception methods	Existing site data	Analysis of ground-water samples from observation wells, geophysics

*May be appropriate if detailed information is required or if it is the only method due to a lack of published data.

Table 3-8. Summary of Atmospheric Information

		Collection Methods	
Information Needed	Purpose or Rationale	Primary	Secondary
Local Climate:	Define recharge, aeolian erosion, evaporation potential, effect of weather patterns on remedial actions, area of deposition of particulates	National Climate Center (NCC) of National Oceanic and Atmospheric Administration; local weather bureaus	Onsite measurements and observations
o Precipitation			
o Temperature			
o Wind speed and direction			
o Presence of inversion layers			
Weather Extremes:	Determine effect of weather extremes on selection and timing of remedial actions, and extremes of depositional areas	NCC; State emergency planning offices; Federal Emergency Management Agency flood insurance studies	
o Storms			
o Floods			
o Winds			
Release Characteristics:	Determine dispersion characteristics of release	Information from source facility, weather services, air monitoring services	Onsite measurements
o Direction and speed of plume movement			
o Rate, amount, temperature of release			
o Relative densities			

The use of a review committee comprised of individuals experienced in conducting ecological investigations is encouraged to provide design, planning, and oversight for these investigations and to follow through to the selection of an environmentally sound remedy. Section 12 of the *Compendium* addresses environmental information that may be needed and potential collection methods.

3.2.3 Define Sources of Contamination

Sources of contamination are often hazardous substances contained in drums, tanks, surface impoundments, waste piles, and landfills. In a practical sense, heavily contaminated media (such as soils) may also be considered sources of contamination, especially if the original source (such as a leaking tank) is no longer present on the site or is no longer releasing contaminants.

Source characterization involves the collection of data describing (1) facility characteristics that help to identify the source location, potential releases, and engineering characteristics that are important in the evaluation of remedial actions; (2) the waste characteristics, such as the type and quantity of contaminants that may be contained in or released to the environment; and (3) the physical or chemical characteristics of hazardous wastes present in the source. Key source characterization data are summarized in Table 3-10.

The location and type of existing containment should be determined for all known sources. In addition, where the hazardous substance remains in containment vessels, the integrity of the containment structure should be determined so that the potential for release and its magnitude can be evaluated. This determination is especially important for buried drums or tanks, because corrosion may be rapid. These data, as well as the data identified in Table 3-10, may be obtained largely through site inspections, mapping, remote sensing, and sampling and analysis. The waste type should be determined for each source. If available waste manifests or facility records can be reviewed, the industrial processes that resulted in generation of the waste should be determined and the types of contaminants usually present in the process waste identified. Often, sources are sampled and analyzed for contaminants found on the Target Compound List (TCL) (formerly the Hazardous Substances List) or other lists such as those developed for RCRA[3]. Quantities of wastes may be estimated for each waste type either from verifiable inventories of containerized wastes, from sampling and analysis, or from physical dimensions of the source. Section 13 of the *Compendium* and *Characterization of Hazardous Waste Sites – A Methods Manual*, Volume II (U.S. EPA, April 1985) describe methods suitable for sampling and analysis.

It may be possible to determine the location and extent of sources and the variation of materials within a waste deposit by nonchemical analysis. Methodologies for this determination, which are described in Section 8 of the *Compendium*, include geophysical surveys. A variety of survey techniques (e.g., ground-penetrating radar, electrical resistivity, electromagnetic induction, magnetometry, and seismic profiling), can effectively detect and map the location and extent of buried waste deposits. Aerial photography and infrared imagery can aid in defining sources through interpretation of the ecological effects that result from stressed biota. However, all of these geophysical methods are nonspecific, and subsequent sampling of the sources will probably be required to provide the data for evaluation of source control measures at the site.

3.2.4 Determine the Nature and Extent of Contamination

The final objective of the field investigations is to characterize the nature and extent of contamination such that informed decisions can be made as to the level of risk presented by the site and the appropriate type(s) of remedial response. This process involves using the information on source location and physical site data (e.g., ground-water flow directions, over land flow patterns) to give a preliminary estimate of the locations of contaminants that may have migrated. An iterative monitoring program is then implemented so that, by using increasingly accurate analytical techniques, the locations and concentrations of contaminants that have migrated into the environment can be documented.

The sampling and analysis approach that should be used is discussed in Section 4.5.1 of the *DQO Guidance*. In short, the approach consists of, where appropriate, initially taking a large number of samples using field screening type techniques and then, based on the results of these samples, taking additional samples – to be analyzed more rigorously – from those locations that showed the highest concentrations in the previous round of sampling. The final step is to document the extent of contamination using an analytical level that yields data quality that is sufficient for the risk assessment and the subsequent analysis and selection of remedial alternatives.

At hazardous waste sites the nature and extent of contamination may be of concern in five media: ground water, soil, surface water, sediments, and air. The methodologies for conducting sampling and analysis for each of these media are discussed below. More detailed descriptions of the investigation

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[3] Guidance on determining whether wastes are RCRA-listed or characteristic wastes can be found in the *CERCLA Compliance with Other Laws Manual* (U.S. EPA, May 1988).

Table 3-9. Summary of Ecological Information

Information Needed for Public Health Evaluation	Purpose or Rationale	Collection Methods	
		Primary	Secondary
Land Use Characteristics	Determine if terrestrial environment could result in human exposure, e.g., through hunting or use of agricultural land	Ground and aerial survey maps; site survey	Ground and aerial surveys
Water Use Characteristics	Determine if aquatic environment could result in human exposure, e.g., through fishing or other recreational water activities	Water resource agency reports; site surveys	
Information Needed for Environmental Evaluation			
Ecosystem Components and Characteristics	Determine potentially affected ecosystems; determine presence of endangered species	Records of area plants and animal surveys, survey of plants and animals on or near a site; survey of a site or area photographs	Ground surveys and sample collection
Critical Habitats	Determine the area on or near a site to be protected during remediation	Records of site environment	Ground and water surveys
Biocontamination	Determine observable impact of contaminants	Records of site environment	Sampling and analysis

Table 3-10. Summary of Source Information

Information Needed	Purpose or Rationale	Collection Methods	
		Primary	Secondary
Facility Characteristics:			
o Source location	Locate above-ground and subsurface contaminant sources	Site inspection facility records, archival photos	Remote sensing, sampling, and analysis
o Type of waste/chemical containment	Determine potential remedies for releases	Site inspection	Remote sensing
o Integrity of waste/chemical containment	Determine probability of release and timing of response	Site inspection	Sampling and analysis; nondestructive testing
o Drainage control	Determine probability of release to surface water	Site inspection; topographic maps	
o Engineeered structures	Identify possible conduits for migration or interference with remedial actions	Site inspection; facility records	Remote sensing
o Site security	Determine potential for exposure by direct contact; may dictate response	Site inspection	
o Known discharge points (outfalls, stacks)	Determine points of accidental or intentional discharge	Site inspection; facility records	

Table 3-10. Continued

Information Needed	Purpose or Rationale	Collection Methods	
		Primary	Secondary
o Mapping and surveying	Locate existing structures and obstructions for alternatives evaluation, site features, and topography	Existing maps (USGS, county, land development)	Remote sensing; surveying
Waste Characteristics:			
o Type	Determine contaminants for exposure assessments and for treatment options	Site inspection; waste manifests	Sampling and analysis
o Quantities	Determine magnitude of potential releases	Site inspection	Sampling and analysis; geophysical surveys
o Chemical and physical properties	Determine environmental mobility, persistence, and effects; determine parameters for development and evaluation of alternatives	Site inspection, handbooks, CHEMTREC/OHMTADS, Chemical Information Service (CIS), and facility records	Sampling and analysis
o Concentrations	Determine quantities and concentrations potentially released to environmental pathways	Site inspection	Sampling and analysis

process can be found in the *DQO Guidance* and the *Compendium*.

3.2.4.1 Ground Water

The nature and extent of ground-water contamination should be evaluated both horizontally and vertically. On the basis of geologic and hydrogeologic investigations, it should be determined if contamination of an aquifer(s) is possible and if such contamination could potentially affect human or environmental receptors. Following this, a ground-water monitoring program may need to be implemented, concentrating the placement of wells in the direction of ground-water flow, in aquifers subject to contamination, and in places where they would indicate an existing or future threat to receptor populations. However, because of the uncertainties associated with subsurface migration, identifying background levels, and determining if there is a contribution from other sources, sampling should also be conducted in the area perceived to be upgradient from the contaminant source.

Because of the significant investment necessary to drill new wells and the resulting limited number of samples, neither Level I nor field-screening techniques are appropriate for analysis of ground water, other than to possibly better define chemical analysis parameters. Geophysical techniques can be useful in identifying the location of plumes and thereby assisting in the location of monitoring wells. However, geophysical techniques are subject to influences from external factors and are not appropriate at all sites. Therefore, care must be taken in employing these methods, and their results should always be confirmed with analytical sampling. Specific guidance on conducting ground water sampling investigations and response activities can be found in the *Compendium*, the *DQO Guidance*, and the "Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites" (U.S. EPA, Draft, August 1988).

3.2.4.2 Soil

As with ground-water sampling, the intent of soil sampling is to characterize and estimate the limits of existing soil contamination. Field-screening techniques (e.g., soil gas analysis, mobile laboratories for target compounds) can be useful for directing soil sampling into areas of greatest contamination or "hot spots." If existing information provides no basis for predicting where hot spots might occur, sampling locations can be chosen in a grid pattern of appropriate size such that investigators can be confident that areas of high concentration have been located. Often, especially if soil has been contaminated as a result of overland flow of contaminants from defined sources, sampling can be concentrated in those areas that, either through topography or evidence such as drainage channels, it is most likely that contaminants have been deposited. As with ground water, soil contamination should be documented in both vertical and horizontal directions. This approach will help determine both areas of contamination and background concentrations. Soils to be analyzed usually can be obtained by hand, allowing many samples to be taken and initially analyzed with instruments such as a photoionization detector. Results of field screening can then be used to determine which samples should be further analyzed using more rigorous methods.

3.2.4.3 Surface Water

Leachate from contaminant sources or discharge of contaminated ground water can result in the contamination of surface waters. Surface-water sampling locations should be chosen at the perceived location(s) of contaminant entry to the surface water and downstream, as far as necessary, to document the extent of contamination. As with soil, the relative ease of obtaining samples allows many samples to be taken and analyzed using field screening methods, a subset of which can be chosen for more rigorous analysis.

Contamination of surface water is sometimes the result of an incidental release of contaminants such as the overflowing or breach of a surface impoundment. In these cases, it is not likely that routine surface water sampling will show contamination that has or may occur. Therefore, to document whether such releases occur, sampling should be conducted during or following periods of heavy rainfall when possible.

3.2.4.4 Sediments

A potentially more serious and common problem associated with surface water is the contamination of sediments. Whereas contamination in surface water tends to become diluted or transformed as it travels downstream, contaminants deposited in sediments tend to remain in place. It is therefore important to monitor for sediment contamination if it is suspected that surface water has been contaminated.

The choice of sampling locations for sediments is similar to the criteria applied to surface-water sampling. Field-screening techniques can be useful in defining areas of contamination. However, it should be noted that sediment contamination often consists of inorganics and/or nonvolatile organics, for which field screening techniques are not as applicable. Therefore, in designing a sampling program, consideration of the contaminants of concern is very important.

3.2.4.5 Air

Volatilization of organics and emissions of airborne particulates can be a concern at hazardous waste sites. For sites at which it appears that air emissions are a problem (e.g., surface impoundments containing volatile organics, landfills at which there is evidence of methane gas production and migration), an air emissions monitoring program should be undertaken. A field-screening program is recommended to determine if there is an air pollution problem, both for volatile organics and fugitive dust emissions. Because of the highly variable nature of air emissions from hazardous waste sites, consideration of meteorological conditions at the time of sampling is essential for the proper documentation of potential air pollution.

3.2.5 *Additional Site Characterization*

In some situations, additional site information may be required to refine our understanding of the site and better evaluate specific remedial alternatives. Examples include:

- Better delineation of contaminated areas and depths of contamination so that quantities of contaminated media to be processed can be calculated more accurately
- Characteristics of the media that would affect the feasibility of the remedial alternative, such as soil permeability for soil-vapor extraction
- Pertinent site characteristics not discovered earlier in the initial site characterization effort

Before additional site characterization is initiated, the QAPP/FSP should be reviewed and modified as appropriate to guide the collection of additional site data. In addition, site data collected and evaluated as part of the initial RI site characterization should be reviewed and compared to the data needs identified for conducting the detailed analysis of alternatives. Reviewing data needs during the preplanning step is also useful in predicting the necessary number of samples and types of analyses required.

3.3 Laboratory Analyses

Data that will be used as the basis for decision-making requires that the analysis of samples in laboratories meets specific QA/QC requirements. To meet these requirements, federal- or state-lead site investigations have the option of using mobile laboratories; the CLP, which is established by EPA; or a non-CLP laboratory that meets the DQOs of the site investigation.[4]

The CLP provides analytical services through a nationwide network of laboratories under contract to EPA. The lead agency chooses whether or not to use a CLP laboratory on the basis of available CLP capacity and the analytical requirements that meet the DQOs. If the CLP is not used, a laboratory may be procured using standard bidding procedures.

Under the CLP, the majority of analytical needs are met through standardized laboratory services provided by Routine Analytical Services (RAS). The RAS program currently provides laboratory services for the analysis of organics and inorganics in water or solid samples. Other specialized types of analysis not yet provided by standardized laboratory contracts may be scheduled on an as-needed basis under the special analytical services (SAS) program. The SAS program is designed to complement the RAS program by providing the capability for specialized or custom analytical requirements. If an analytical need is not ordinarily provided by routine analytical services (RAS), a specific subcontract can be awarded under the SAS program to meet a particular requirement.

The decision whether to use mobile laboratories or a CLP or non-CLP laboratory should be based on several factors including the analytical services required, the number of samples to be analyzed, the desired turnaround time, and the anticipated turnaround time of the laboratory at the time samples are to be sent. Mobile or non-CLP laboratories located close to the site may be the best choice when fast turnaround of analytical results is required to meet specific sampling objectives or would result in a significant reduction of the overall RI/FS schedule. To facilitate the most efficient completion of the RI, mobile or non-CLP laboratories can be used to initially document the nature and extent of contamination. Selected duplicate samples can be sent to CLP laboratories to confirm and validate the analytical results from the mobile or non-CLP laboratories. This process assists in the timely completion of the RI and the initiation of FS activities, while still ensuring that legally defensible data are available for decision-making and potential cost-recovery actions.

If a non-CLP laboratory is used, analytical protocols need to be specified in the bid packages sent to laboratories that are under consideration. For federal-lead sites, laboratories receiving invitations to bid have usually been approved by the EPA Regional QA representative. For state-lead sites at which non-CLP laboratories are used, the laboratory usually subcontracts with the prime contractor when the project is initiated.

Section 5 of the *Compendium* presents the details of procedures for the use of CLP laboratories and non-CLP laboratories. The *User's Guide to the Contract*

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[4] The type of laboratory analyses that will be utilized for a PRP-lead RI/FS may also include any of those listed above, if approved by the RPM (See Appendix A).

Laboratory Program (U.S. EPA, December 1986) also presents procedures for use of the CLP.

3.4 Data Analyses

Analyses of the data collected should focus on the development or refinement of the conceptual site model by presenting and analyzing data on source characteristics, the nature and extent of contamination, the contaminated transport pathways and fate, and the effects on human health and the environment. Data collection and analysis for the site characterization is complete when the DQOs that were developed in scoping (including any revisions during the RI) are met, when the need (or lack thereof) for remedial actions is documented, and when the data necessary for the development and evaluation of remedial alternatives have been obtained. The results of the RI typically are presented as an analysis of site characteristics and the risk associated with such characteristics (i.e., the baseline risk assessment).

3.4.1 Site Characteristics

The evaluation of site characteristics should focus on the current extent of contamination and estimating the travel time to, and predicting contaminant concentrations at, potential exposure points. Data should be analyzed to describe (1) the site physical characteristics, (2) the source characteristics, (3) the nature and extent of contamination, and (4) the important contaminant fate and transport mechanisms.

3.4.1.1 Site Physical Characteristics

Data on site physical characteristics should be analyzed to describe the environmental setting at the site, including important surface features, soils, geology, hydrology, meteorology, and ecology. This analysis should emphasize factors important in determining contaminant fate and transport for those exposure pathways of concern. For example, if migration of contamination in ground water is of concern, these factors may include the properties of the unsaturated zone, the rate and direction of flow in the aquifer(s), and the extent of subsurface systems.

3.4.1.2 Source Characteristics

Data on source characteristics should be analyzed to describe the source location; the type and integrity of any existing waste containment; and the types, quantities, chemical and physical properties, and concentrations of hazardous substances found. The actual and potential magnitude of releases from the source and the mobility and persistence of source contaminants should be evaluated.

3.4.1.3 The Nature and Extent of Contamination

An analysis of data collected concerning the study area should be performed to describe contaminant concentration levels found in environmental media in the study area. Analyses that are important to the subsequent risk assessment and subsequent development of remedial alternatives include the horizontal and vertical extent of contamination in soil, ground water, surface water, sediment, air, biota, and facilities.[5] Spatial and temporal trends in contamination may be important in evaluating transport pathways. Data should be arranged in tabular or graphical form for clarity. Figure 3-2 shows an example of how the extent of soil and ground-water contamination can be represented in terms of excess lifetime cancer risk. Similar figures can be prepared showing concentrations rather than risk values.

3.4.1.4 Contaminant Fate and Transport

Results of the site physical characteristics, source characteristics, and extent of contamination analyses are combined in the analyses of contaminant fate and transport. If information on the contaminant release is available, the observed extent of contamination may be used in assessing the transport pathway's rate of migration and the fate of contaminants over the period between release and monitoring. Contaminant fate and transport may also be estimated on the basis of site physical characteristics and source characteristics.

Either analysis may use analytical or numerical modeling. While field data generally best define the extent of contamination, models can interpolate among and extrapolate from isolated field samples and can interpret field data to create a more detailed description. Models also can aid the data reduction process by providing the user with a structure for organizing and analyzing field data.

Models applicable to site characterization can be grouped according to their relative accuracy and their ability to depict site conditions. Simplified models (e.g., analytical and semianalytical models) can quantitatively estimate site conditions with relatively low accuracy and resolution. Typically, they provide order-of-magnitude estimates and require that simplified assumptions be made regarding site conditions and chemical characteristics.

More detailed numerical models (e.g., numerical computer codes) provide greater accuracy and resolution because they are capable of representing spatial variations in site characteristics and irregular geometries commonly found at actual sites. These models can also represent the actual configuration and effects of remedial actions on site conditions. Detailed mathematical models are sometimes appropriate for investigations in which detailed information on contaminant fate and transport is required.

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[5] Cross-media contamination should be considered (e.g., potential for contaminated soils to act as a source for ground-water contamination due to leaching from the soil).

Models also are useful for screening alternative remedial actions and may be used for a detailed analysis of alternatives. Deciding whether analytical or numerical models should be used and selecting appropriate models for either the remedial investigation or the feasibility study can be difficult. Modeling may not be needed if site conditions are well understood and if the potential effectiveness of different remedial actions can be easily evaluated. In selecting and applying models, it is important to remember that a model is an artificial representation of a physical system and is only one way of characterizing and assessing a site. A model cannot replace, nor can it be more accurate than, the actual site data. Additional information on determining contaminant fate and transport is provided in the "Superfund Exposure Assessment Manual" (U.S. EPA, April 1988).

3.4.2 *Baseline Risk Assessment*

3.4.2.1 General Information

Baseline risk assessments provide an evaluation of the potential threat to human health and the environment in the absence of any remedial action. They provide the basis for determining whether or not remedial action is necessary and the justification for performing remedial actions. The baseline risk assessment will also be used to support a finding of imminent and substantial endangerment if such a finding is required as part of an enforcement action. Detailed guidance on evaluating potential human health impacts as part of this baseline assessment is provided in the *Superfund Public Health Evaluation Manual (SPHEM)* (U.S. EPA, October 1986).[6] Guidance for evaluating ecological risks is currently under development within OSWER.

In general, the objectives of a baseline risk assessment may be attained by identifying and characterizing the following:

- Toxicity and levels of hazardous substances present in relevant media (e.g., air, ground water, soil, surface water, sediment, and biota)
- Environmental fate and transport mechanisms within specific environmental media such as physical, chemical, and biological degradation processes and hydrogeological conditions
- Potential human and environmental receptors
- Potential exposure routes and extent of actual or expected exposure
- Extent of expected impact or threat; and the likelihood of such impact or threat occurring (i.e., risk characterization)
- Level(s) of uncertainty associated with the above items

The level of effort required to conduct a baseline risk assessment depends largely on the complexity of the site. The goal is to gather sufficient information to adequately and accurately characterize the potential risk from a site, while at the same time conduct this assessment as efficiently as possible. Use of the conceptual site model developed and refined previously will help focus investigation efforts and, therefore, streamline this effort. Factors that may affect the level of effort required include:

- The number, concentration, and types of chemicals present
- Areal extent of contamination
- The quality and quantity of available monitoring data
- The number and complexity of exposure pathways (including the complexity of release sources and transport media)
- The required precision of sample analyses, which in turn depends on site conditions such as the extent of contaminant migration and the proximity, characteristics, and size of potentially exposed population(s)
- The availability of appropriate standards and/or toxicity data

3.4.2.2 Components of the Baseline Risk Assessment

The risk assessment process can be divided into four components:

- Contaminant identification
- Exposure assessment
- Toxicity assessment

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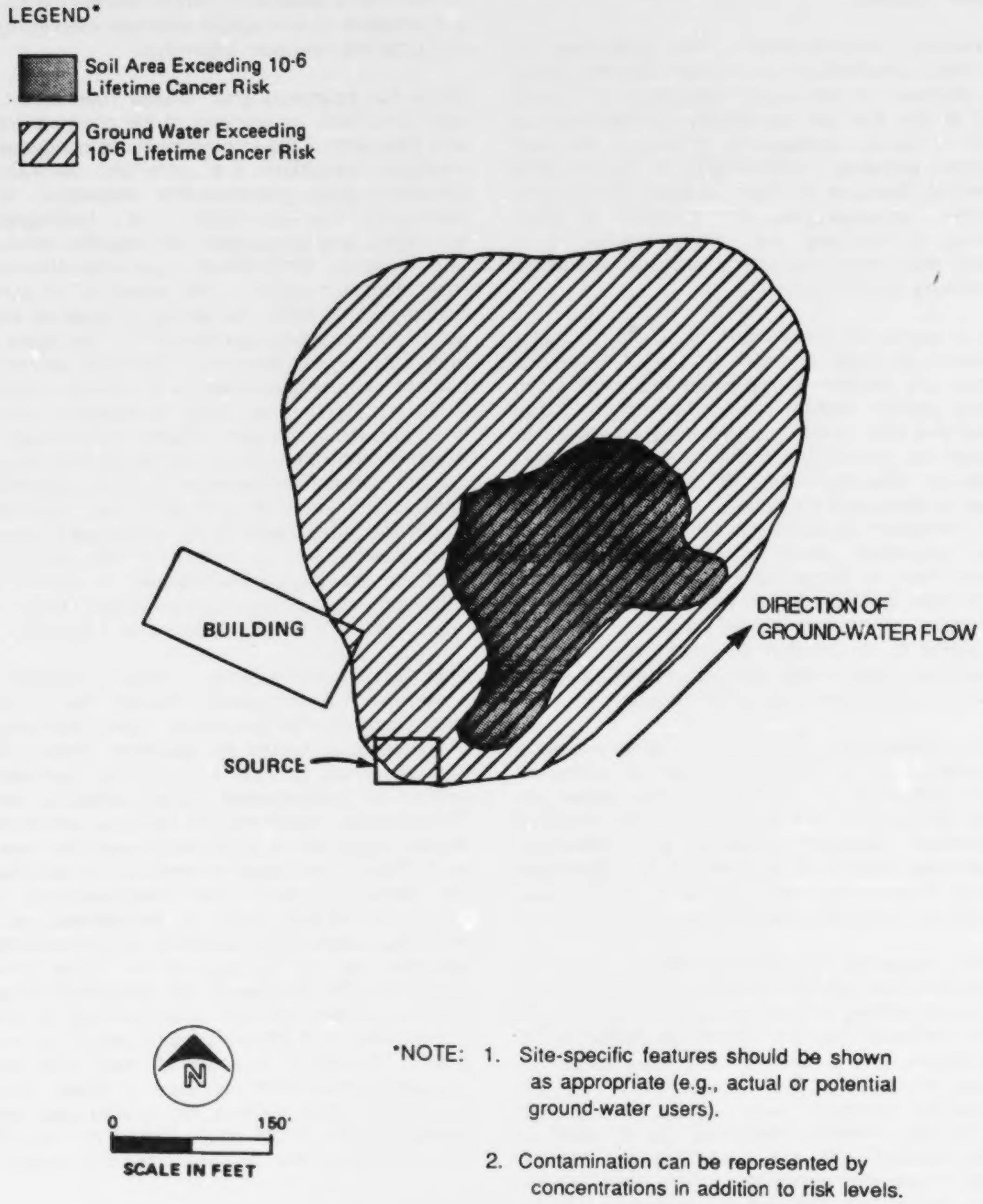
[6] This guidance is currently undergoing revision.


LEGEND*
Soil Area Exceeding 10^{-6} Lifetime Cancer Risk
Ground Water Exceeding 10^{-6} Lifetime Cancer Risk
BUILDING
SOURCE
DIRECTION OF GROUND-WATER FLOW
N
0
150'
SCALE IN FEET

*NOTE:

1. Site-specific features should be shown as appropriate (e.g., actual or potential ground-water users).
2. Contamination can be represented by concentrations in addition to risk levels.

Figure 3-2. Representation of the areal extent of contamination.

- Risk characterization

Figure 3-3 illustrates the risk assessment process and its four components. A brief overview of each component follows.

Contaminant Identification. The objective of contaminant identification is to screen the information that is available on hazardous substances or wastes present at the site and to identify contaminants of concern to focus subsequent efforts in the risk assessment process. Contaminants of concern may be selected because of their intrinsic toxicological properties, because they are present in large quantities, or because they are presently in or potentially may move into critical exposure pathways (e.g., drinking water supply).

It may be useful for some sites to select "indicator chemicals" as part of this process.[7] Indicator chemicals are chosen to represent the most toxic, persistent, and/or mobile substances among those identified that are likely to significantly contribute to the overall risk posed by the site. In some instances, an indicator chemical may be selected for the purpose of representing a "class" of chemicals (e.g., TCE to represent all volatiles). Although the use of indicator chemicals serves to focus and streamline the assessment on those chemicals that are likely to be of greatest concern, a final check will need to be made during remedy selection and the remedial action phase to ensure that the waste management strategy being implemented addresses risks posed by the range of contaminants found at the site.

Exposure Assessment. The objectives of an exposure assessment are to identify actual or potential exposure pathways, to characterize the potentially exposed populations, and to determine the extent of the exposure. Detailed guidance on conducting exposure assessments is provided in the *Superfund Exposure Assessment Manual* (U.S. EPA, April 1988), and is briefly discussed below.

Identifying potential exposure pathways helps to conceptualize how contaminants may migrate from a source to an existing or potential point of contact. An exposure pathway may be viewed as consisting of four elements: (1) A source and mechanism of chemical release to the environment; (2) An environmental transport medium (e.g., air, ground water) for the released chemical; (3) A point of potential contact with the contaminated medium (referred to as the exposure point); and (4) An exposure route (e.g., inhalation, ingestion) at the exposure point.

The analysis of the contaminant source and how contaminants may be released involves characterizing the contaminants of concern at the site and determining the quantities and concentrations of contaminants released to environmental media. Figure 3-4 presents a conceptual example identifying actual and potential exposure pathways.

Once the source(s) and release mechanisms have been identified, an analysis of the environmental fate and transport of the contaminants is conducted. This analysis considers the potential environmental transport (e.g., ground-water migration, airborne transport); transformation (e.g., biodegradation, hydrolysis, and photolysis); and transfer mechanisms (e.g., sorption, volatilization) to provide information on the potential magnitude and extent of environmental contamination. Next, the actual or potential exposure points for receptors are identified. The focus of this effort should be on those locations where actual contact with the contaminants of concern will occur or is likely to occur. Last, potential exposure routes that describe the potential uptake mechanism (e.g., ingestion, inhalation, etc.) once a receptor comes into contact with contaminants in a specific environmental medium are identified and described. Environmental media that may need to be considered include air, ground water, surface water, soil and sediment, and food sources. Detailed procedures for estimating and calculating rates of exposure are described in detail in the *Superfund Exposure Assessment Manual.*

After the exposure pathway analysis is completed, the potential for exposure should be assessed. Information on the frequency, mode, and magnitude of exposure(s) should be gathered. These data are then assessed to yield a value that represents the amount of contaminated media contacted per day. This analysis should include not only identification of current exposures but also exposures that may occur in the future if no action is taken at the site. Because the frequency mode and magnitude of human exposures will vary based on the primary use of the area (e.g., residential, industrial, or recreational), the expected use of the area in the future should be evaluated.[8]The purpose of this analysis is to provide decision-makers with an understanding of both the current risks and potential future risks if no action is taken. Therefore, as part of this evaluation, a reasonable maximum exposure scenario should be developed, which reflects the type(s) and extent of exposures that could occur based on the likely or expected use of the site (or surrounding areas) in the future.[9] The reasonable maximum exposure scenario is presented to the decision-maker so that possible implications of decisions regarding how to best manage uncertainties can be factored into the risk management remedy selection.

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[7] The methodology for identifying indicator chemicals for assessing human health risks is described in the *Superfund Public Health Evaluation Manual* (U.S. EPA, October 1986).

[8] This evaluation does not require an extensive analysis of demographic trends and a statistically measurable confidence level for the prediction of future development, only that the likely use (based on past and current trends, zoning restrictions, etc.) be evaluated.

The final step in the exposure assessment is to integrate the information and develop a qualitative and/or quantitative estimate of the expected exposure level(s) resulting from the actual or potential release of contaminants from the site.

Toxicity Assessment. Toxicity assessment, as part of the Superfund baseline risk assessment process, considers (1) the types of adverse health or environmental effects associated with individual and multiple chemical exposures; (2) the relationship between magnitude of exposures and adverse effects; and (3) related uncertainties such as the weight of evidence for a chemical's potential carcinogenicity in humans. Detailed guidance for conducting toxicity assessments is provided in the *SPHEM.*

Typically, the Superfund risk assessment process relies heavily on existing toxicity information and does not involve the development of new data on toxicity or dose-response relationships. Available information on many chemicals is already evaluated and summarized by various EPA program offices or cross-Agency work groups in health and environmental effects assessment documents. These documents or profiles will generally provide sufficient toxicity and dose-response information to allow both qualitative and quantitative estimates of risks associated with many chemicals found at Superfund sites. These documents often estimate carcinogen exposures associated with specific lifetime cancer risks (e.g., risk-specific doses or RSDs), and systemic toxicant exposures that are not likely to present appreciable risk of significant adverse effects to human populations over a lifetime (e.g., Reference Doses or RfDs).

Risk Characterization. In the final component of the risk assessment process, a characterization of the potential risks of adverse health or environmental effects for each of the exposure scenarios derived in the exposure assessment, is developed and summarized. Estimates of risks are obtained by integrating information developed during the exposure and toxicity assessments to characterize the potential or actual risk, including carcinogenic risks, noncarcinogenic risks, and environmental risks. The final analysis should include a summary of the risks associated with a site including each projected exposure route for contaminants of concern and the distribution of risk across various sectors of the population. In addition, such factors as the weight-of-evidence associated with toxicity information, and any uncertainties associated with exposure assumptions should be discussed.

Characterization of the environmental risks involves identifying the potential exposures to the surrounding ecological receptors and evaluating the potential effects associated with such exposure(s). Important factors to consider include disruptive effects to populations (both plant and animal) and the extent of perturbations to the ecological community.

The results of the baseline risk assessment may indicate that the site poses little or no threat to human health or the environment. In such situations, the FS should be either scaled down as appropriate to that site and its potential hazard, or eliminated altogether. The results of the RI and the baseline risk assessment will therefore serve as the primary means of documenting a no-action decision. If it is decided that the scope of the FS will be less than what is presented in this guidance or eliminated altogether, the lead agency should document this decision and receive the concurrence of the support agency.

3.4.3 Evaluate Data Needs

As data are collected and a better understanding of the site and the risks that it poses are obtained, the preliminary remedial action alternatives developed during scoping should be reviewed and refined. The available data should be evaluated to determine if they are sufficient to develop remedial alternatives. If they are not, additional data gathering will be required. When sufficient data are available, remedial response objectives with respect to the contaminants of concern, the areas and volumes of contaminated media, and existing and potential exposure routes and receptors of concern can be developed as part of the FS.

3.5 Data Management Procedures

An RI may generate an extensive amount of information, the quality and validity of which must be consistently well documented because this information will be used to support remedy selection decisions and any legal or cost recovery actions. Therefore, field sampling and analytical procedures for the acquisition and compilation of field and laboratory data are subject to data management procedures.[10] The discussion on data management

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[9] Additional guidance on developing reasonable maximum exposure scenarios will be provided in the upcoming revision of the *SPHEM.*

[10] DQOs will govern the data management procedures used, and the QAPP/FSP will identify both field-collected and analytical data. Information to be recorded should include sampling information, recording procedures, sample management, and QC concerns.

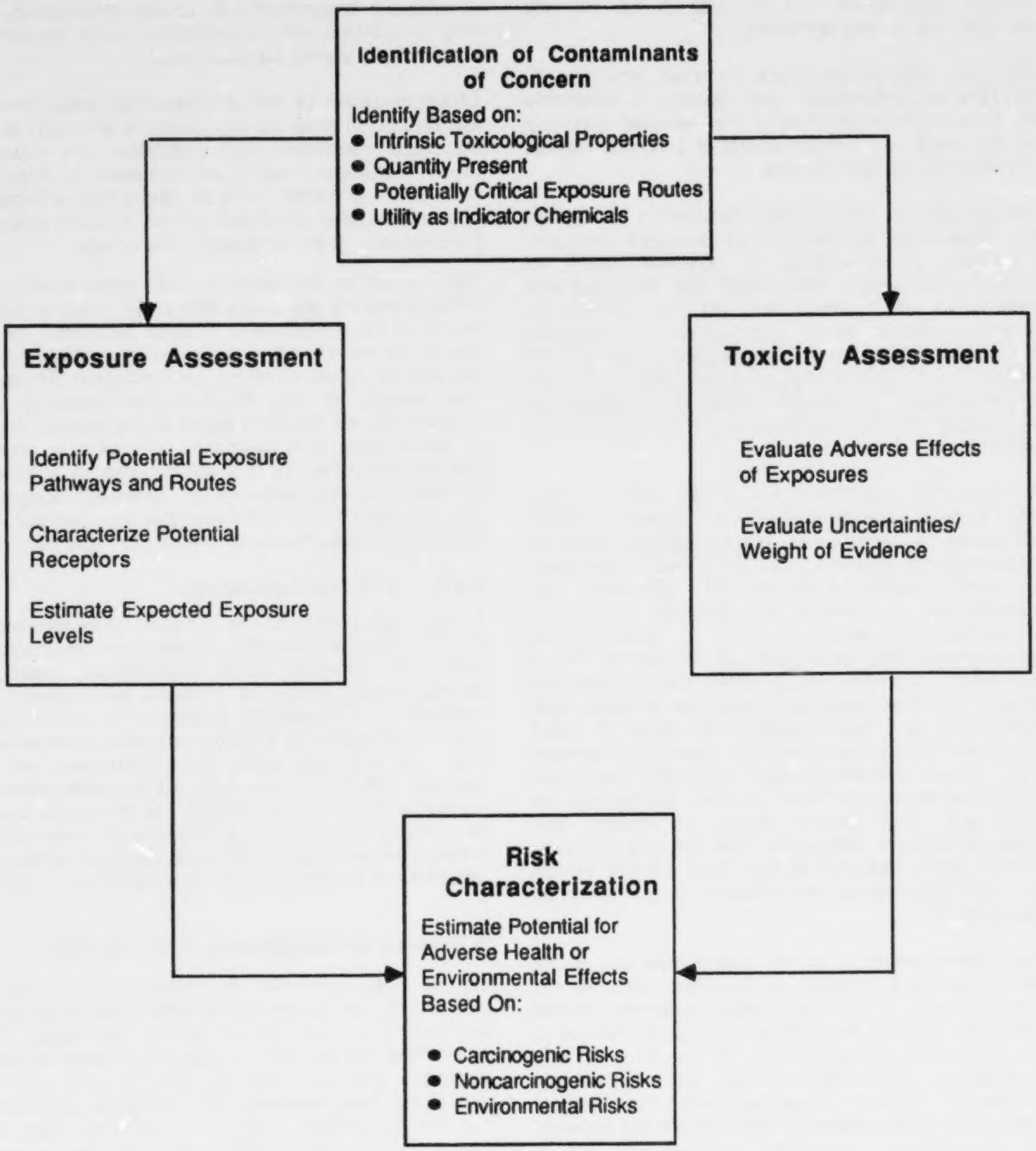
Identification of Contaminants of Concern
Identify Based on:
● Intrinsic Toxicological Properties
● Quantity Present
● Potentially Critical Exposure Routes
● Utility as Indicator Chemicals
Exposure Assessment
Identify Potential Exposure Pathways and Routes
Characterize Potential Receptors
Estimate Expected Exposure Levels
Toxicity Assessment
Evaluate Adverse Effects of Exposures
Evaluate Uncertainties/ Weight of Evidence
Risk Characterization
Estimate Potential for Adverse Health or Environmental Effects Based On:
● Carcinogenic Risks
● Noncarcinogenic Risks
● Environmental Risks

Figure 3-3. Components of the risk assessment process.

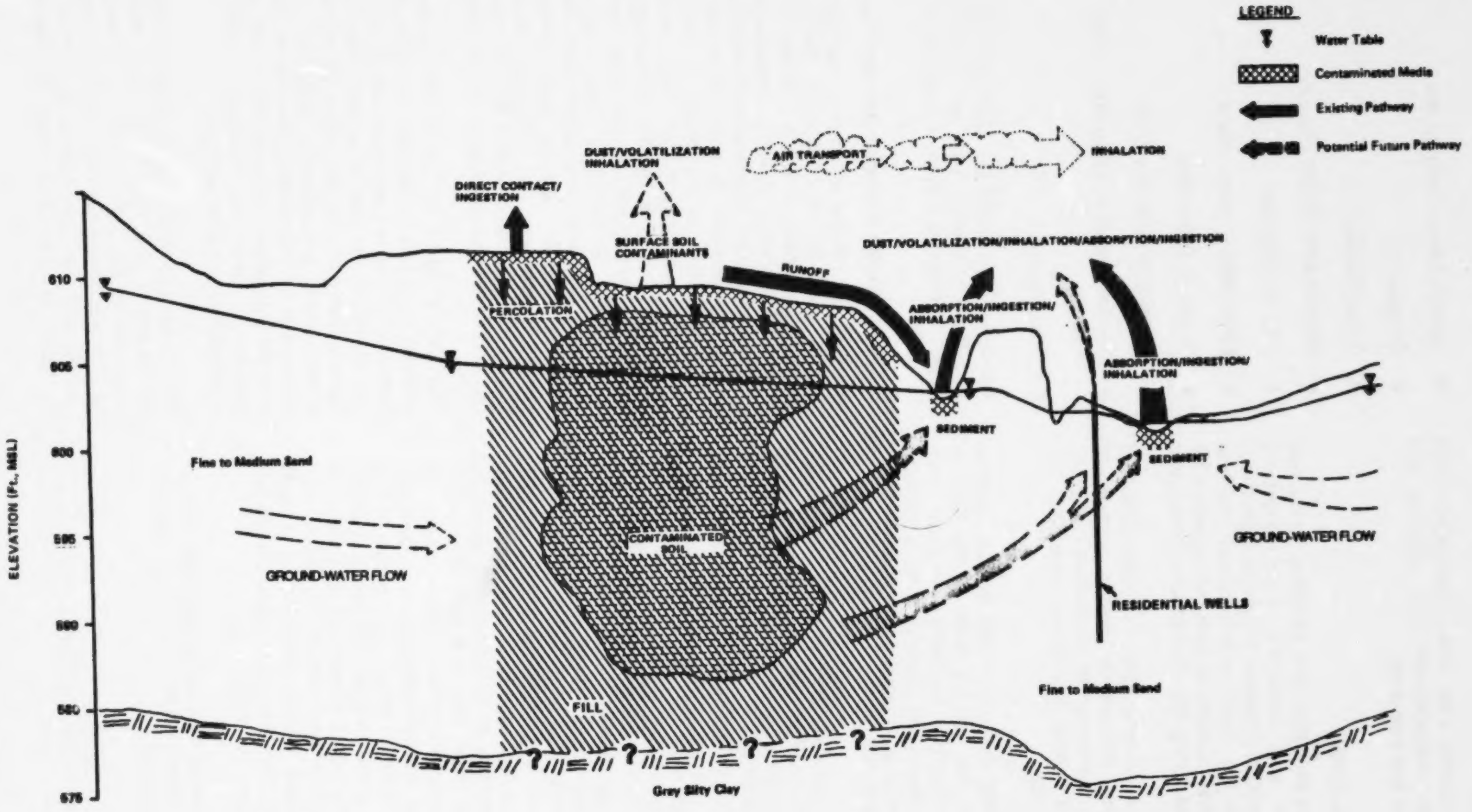
LEGEND
Water Table
Contaminated Media
Existing Pathway
Potential Future Pathway
DIRECT CONTACT/ INGESTION
DUST/VOLATILIZATION INHALATION
AIR TRANSPORT
INHALATION
SURFACE SOIL CONTAMINANTS
RUNOFF
DUST/VOLATILIZATION/INHALATION/ABSORPTION/INGESTION
ABSORPTION/INGESTION/ INHALATION
ABSORPTION/INGESTION/ INHALATION
PERCOLATION
SEDIMENT
SEDIMENT
CONTAMINATED SOIL
FILL
RESIDENTIAL WELLS
Fine to Medium Sand
Fine to Medium Sand
GROUND-WATER FLOW
GROUND-WATER FLOW
Gray Silty Clay
ELEVATION (Ft., MSL)
610
605
600
595
590
580
575

Figure 3-4. Identification of exposure pathways.

procedures is divided into three categories: field activities, sample management and tracking, and document control and inventory.

3.5.1 *Field Activities*

During site characterization and sampling, consistent documentation and accurate recordkeeping procedures are critical because subsequent decisions will be made on the basis of information gathered during these tasks. Aspects of data management for sampling activities during site characterization include:

- Quality Assurance/Quality Control (QA/QC) Plans – These documents provide records of responsibility, adherence to prescribed protocols, nonconformity events, corrective measures, and data deficiencies.
- A Data Security System – This system outlines the measures that will be taken in the field to safeguard chain-of-custody records and prevent free access to project records, thereby guarding against accidental or intentional loss, damage, or alteration.
- Field Logs – The daily field logs are the primary record for field investigation activities and should include a description of any modifications to the procedures outlined in the work plan, field sampling plan, or health and safety plan, with justifications for such modifications. Field measurements and observations should be recorded directly into the project log books. Examples of field measurements include pH, temperature, conductivity, water flow, air quality parameters, and soil characteristics. Health and safety monitoring, sampling locations, sampling techniques, and a general description of daily activity are typically included in the daily log. Any unusual occurrences or circumstances should be documented in these logs and can be used for reference in determining the possible causes for data anomalies discovered during data analysis. Data must be recorded directly and legibly in field log books with entries signed and dated. Changes made to original notes should not obliterate the original information and should be dated and signed. Standard format information sheets should be used whenever appropriate and should be retained in permanent files.

Documentation involved in maintaining field sample inventories and proper chain-of-custody records may include the following[11]:

- Sample Identification Matrix
- Sample Tag
- Traffic Report
- High-Hazard Traffic Report
- SAS Packing List
- Chain-of-Custody Form
- Notice of Transmittal
- Receipt for Samples Form
- Central Regional Laboratory (CRL) Sample Data Report
- Shipping Airbill

Additional information for each of these items, along with the instructions for their completion, can be found in Section 6.2 of the *Compendium*.

3.5.2 *Sample Management and Tracking*

A record of sample shipments, receipt of analytical results, submittal of preliminary results for QA/QC review, completion of QA/QC review, and evaluation of the QC package should be maintained to ensure that only final and approved analytical data are used in the site analysis. In some instances, the use of preliminary data is warranted to prepare internal review documents, begin data analysis while minimizing lost time for the turnaround of QA/QC comments, and continue narrowing remedial action alternatives. Preliminary data are considered unofficial, however, and preliminary data used in analyses must be updated upon receipt of official QA/QC comments and changes. Sample results should not be incorporated in the site characterization report unless accompanied by QA/QC comments.

The DQOs stated for each task involving sample analysis must specify whether the information is valid with qualifiers or not and must specify which qualifiers can invalidate the use of certain data. For instance, reproducibility of plus or minus 20 percent may be acceptable in a treatability study but may not be acceptable for determining the risk to human health from drinking water. Acceptability of data quality is not established until the reviewed QA/QC package accompanies the analytical data.

The acceptable QA/QC package should be defined in the approved site QAPP for each discrete task. Where use of the CLP is involved, review by the CRL QA Office is typical but may vary from one Region to the next and may vary from one state to the next in the case of state-lead sites. Nevertheless, the

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[11] Specific requirements may vary between state- and federal-lead sites.

DQOs outlined for the use of the data will dictate the level of review required.

3.5.3 *Document Control and Inventory*

Sample results should be managed in a standardized form to promote easy reporting of data in the site characterization report. Precautions should be taken in the analysis and storage of the data collected during site characterization to prevent the introduction of errors or the loss or misinterpretation of data.

The document inventory and filing systems can be set up on the basis of serially numbered documents. These systems may be manual or automated. A suggested structure and sample contents of a file for Superfund activities are shown in Table 3-11. The relationship of this filing system to the Administrative Record is discussed in the "Interim Guidance on Administrative Records for Selection of CERCLA Response Actions" (U.S. EPA, Draft, June 1988).

3.6 Community Relations Activities During Site Characterization

Two-way communication with interested members of the community should be maintained throughout the RI. The remedial project manager and Community Relations Coordinator keep local officials and concerned citizens apprised of site activities and of the schedule of events by implementing several community relation activities. These actions are usually delineated in the community relations plan and typically include, but are not limited to, public information meetings at the beginning and end of the RI; a series of fact sheets that will be distributed to the community during the investigation and will describe up-to-date progress and plans for remedial activities; telephone briefings for key members of the community, public officials and representatives of concerned citizens, and periodic news releases that describe progress at the site.

The files containing the Administrative Record should be established once the RI/FS work plan is finalized and kept at or near the site. It is recommended that the files containing the Administrative Record be kept at one of the information repositories for public information at or near the site and near available copying facilities. Copies of site-related information should be made available to the community and should typically include the RI/FS work plan, a summary of monitoring results, fact sheets, and the community relations plan. The objective of community relations activities during the RI is to educate the public on the remedial process and keep the community informed of project developments as they occur, thereby reducing the likelihood of conflict arising from a lack of information, misinformation, or speculation. As directed in the community relations

Table 3-11. Outline of Suggested File Structure for Superfund Sites

Congressional Inquiries and Hearings:
- Correspondence
- Transcripts
- Testimony
- Published hearing records

Remedial Response:
- Discovery
  - Initial investigation reports
  - Preliminary assessment report
  - Site inspection report
  - Hazard Ranking System data

Remedial planning
- Correspondence
- Work plans for RI/FS
- RI/FS reports
- Health and safety plan
- QA/QC plan
- Record of decision/responsiveness summary

Remedial implementation
- Remedial design reports
- Permits
- Contractor work plans and progress reports
- Corps of Engineers agreements, reports, and correspondence

State and other agency coordination
- Correspondence
- Cooperative agreement/Superfund state contract
- State quarterly reports
- Status of state assurances
- Interagency agreements
- Memorandum of Understanding with the state

Community relations
- Interviews
- Correspondence
- Community relations plan
- List of people to contact, e.g., local officials, civic leaders, environmental groups
- Meeting summaries
- Press releases
- News clippings
- Fact sheets
- Comments and responses
- Transcripts
- Summary of proposed plan
- Responsiveness summary

Imagery:
- Photographs
- Illustrations
- Other graphics

Enforcement:
- Status reports
- Cross-reference to any confidential enforcement files and the person to contact
- Correspondence
- Administrative orders

Contracts
- Site-specific contracts
- Procurement packages
- Contract status notifications
- List of contractors

Financial Transactions:
- Cross-reference to other financial files and the person to contact
- Contractor cost reports
- Audit reports

plan, all activities should be tailored to the community and to the site.

3.7 Reporting and Communication During Site Characterization

During site characterization, communication is required between the lead agency and the support agency.[12] In addition to routine communication between members of the lead agency and their contractor on project progress, written communication is required between the lead agency and the support agency as follows:

1. The lead agency should provide the draft work plan to the support agency for review and comment (discussed in Chapter 2.)
2. The lead agency should provide information on contaminant types and affected media to the support agency for ARAR identification (chemical- and location-specific ARAR determinations are finalized once the site characterization is complete).
3. The lead agency should provide data obtained during site characterization to ATSDR.[13]
4. The lead agency should provide a preliminary summary of site characterization to the support agency (this may serve as the mechanism for ARAR identification).
5. The lead agency should provide a draft RI report for review and comment by the support agency.

Table 3-12 summarizes the points during site characterization when written or oral communication is recom-mended.

3.7.1 Information for ARAR Identification

The information for the support agency's use in identifying ARARs should include a description of the contaminants of concern, the affected media, and any physical features that may help identify location-specific ARARs. This information may be supplied by the preliminary site characterization summary (as discussed below) or by a letter or other document. The support agency shall provide location- and chemical-specific ARARs to the lead agency before preparation of the draft RI report.

3.7.2 Preliminary Site Characterization Summary

A summary of site data following the completion of initial field sampling and analysis should be prepared. This summary should *briefly* review the analytical results of investigative activities to provide the lead agency with a reference for evaluating the development and screening of remedial alternatives. In addition, the preliminary site characterization summary may be used to assist the support agency in identification of ARARs and provide ATSDR with data (prior to issuance of the draft RI) to assist in their health assessment efforts.

The format of this summary is optional and is left to the discretion of the lead-agency RPM. The format may range from a technical memorandum, which simply lists the locations and quantities of contaminants at the site, to a rough draft of the first four chapters of the RI report (see Table 3-13). Use of the technical memorandum and a progress meeting is *strongly* encouraged over the latter to better facilitate RI/FS schedules and sampling progress in the field.

3.7.3 Draft RI Report

A draft RI report should be produced for review by the support agency and submitted to ATSDR for its use in preparing a health assessment and also serve as documentation of data collection and analysis in support of the FS. The draft RI report can be prepared any time between the completion of the baseline risk assessment and the completion of the draft FS. Therefore, *the draft RI report should not delay the initiation or execution of the FS.*

Table 3-13 gives a suggested format for the draft RI report. The report should focus on the media of concern and, therefore, does not need to address all the site characteristics listed, only those appropriate at that specific site.

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[12] Reporting and communicating during a PRP-lead RI/FS is discussed in Appendix A and in the forthcoming "Draft Guidance on Oversight of Potentially Responsible Party Remedial Investigations and Feasibility Studies."

[13] Guidance for coordinating remedial and ATSDR health assessment activities is provided in OSWER Directive 9285.4-02.

Table 3-12. Reporting and Communication During Site Characterization

Information Needed	Purpose	Potential Methods of Information Provision
Need to rescope field activities on the basis of results of field observations	Needed only if screening indicates that field activities need to be rescoped; for lead agency and contractor to identify methods to improve effectiveness of site characterization activities; for lead agency to obtain support agency review and concurrence	Meeting Tech memo Other
Need to rescope field activities on the basis of results of sample analysis	Needed only if analysis of laboratory data indicates field activities need to be rescoped; for lead agency and contractor to identify methods to improve effectiveness of site characterization activities; for lead agency to obtain support agency review and concurrence	Meeting Tech memo Other
Preliminary results of field investigation tasks (e.g., geophysical expolorations, monitoring well installation, etc.)	Provided by the contractor to the lead agency; need and method of communication at lead agency's discretion	Tech memos Other
Descriptive and analytical results of initial site characterization results (excluding risk assessment)	Provides lead agency with early summary of site data; assists in supporting agency with identification of ARARs; may also be submitted to ATSDR for use in preparing health assessment.	Preliminary site characterization summary
Listing of contaminants, affected media; location of wetlands, historic sites, etc.	For support agency's use in identifying chemical- and location-specific ARARs.	Preliminary site characterization summary
Refined remedial action objectives	For lead agency and contractor to define the basis for developing remedial action alternatives; obtain review and comment from the support agency	Meeting Tech memo Other
Documentation of site characterization field activities and analyses including any treatability testing	Required for members of lead agency and their contractor to prepare for public comment and FS support documentation	Draft RI report

Table 3-13. Suggested RI Report Format

Executive Summary

1. Introduction
    - 1.1 Purpose of Report
    - 1.2 Site Background
        - 1.2.1 Site Description
        - 1.2.2 Site History
        - 1.2.3 Previous Investigations
    - 1.3 Report Organization
2. Study Area Investigation
    - 2.1 Includes field activities associated with site characterization. These may include physical and chemical monitoring of some, but not necessarily all, of the following:
        - 2.1.1 Surface Features (topographic mapping, etc.) (natural and manmade features)
        - 2.1.2 Contaminant Source Investigations
        - 2.1.3 Meteorological Investigations
        - 2.1.4 Surface-Water and Sediment Investigations
        - 2.1.5 Geological Investigations
        - 2.1.6 Soil and Vadose Zone Investigations
        - 2.1.7 Ground-Water Investigations
        - 2.1.8 Human Population Surveys
        - 2.1.9 Ecological Investigations
    - 2.2 If technical memoranda documenting field activities were prepared, they may be included in an appendix and summarized in this report chapter.
3. Physical Characteristics of the Study Area
    - 3.1 Includes results of field activities to determine physical characteristics. These may include some, but not necessarily all, of the following:
        - 3.1.1 Surface Features
        - 3.1.2 Meteorology
        - 3.1.3 Surface-Water Hydrology
        - 3.1.4 Geology
        - 3.1.5 Soils
        - 3.1.6 Hydrogeology
        - 3.1.7 Demography and Land Use
        - 3.1.8 Ecology
4. Nature and Extent of Contamination
    - 4.1 Presents the results of site characterization, both natural chemical components and contaminants in some, but not necessarily all, of the following media:
        - 4.1.1 Sources (lagoons, sludges, tanks, etc.)
        - 4.1.2 Soils and Vadose Zone
        - 4.1.3 Ground Water
        - 4.1.4 Surface Water and Sediments
        - 4.1.5 Air
5. Contaminant Fate and Transport
    - 5.1 Potential Routes of Migration (i.e., air, ground water, etc.)
    - 5.2 Contaminant Persistence
        - 5.2.1 If they are appliable (i.e., for organic contaminants), describe estimated persistence in the study area environment and physical, chemical, and/or biological factors of importance for the media of interest.
    - 5.3 Contaminant Migration
        - 5.3.1 Discuss factors affecting contaminant migration for the media of importance (e.g., sorption onto soils, solubility in water, movement of ground water, etc.)
        - 5.3.2 Discuss modeling methods and results, if applicable.
6. Baseline Risk Assessment
    - 6.1 Human Health Evaluation
        - 6.1.1 Exposure Assessment
        - 6.1.2 Toxicity Assessment
        - 6.1.3 Risk Characterization
    - 6.2 Environmental Evaluation

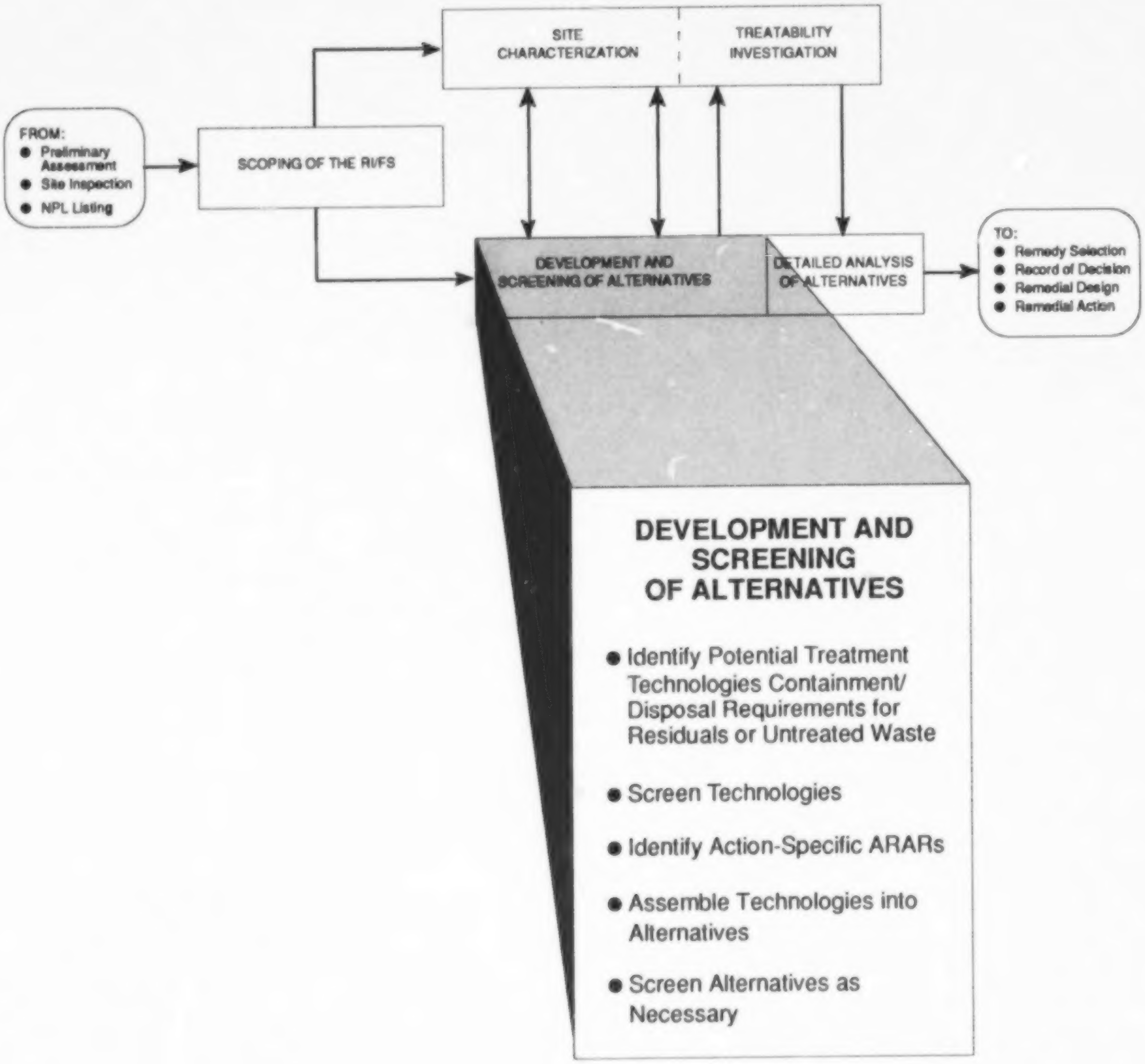
Table 3-13 Continued

7. Summary and Conclusions
    - 7.1 Summary
        - 7.1.1 Nature and Extent of Contamination
        - 7.1.2 Fate and Transport
        - 7.1.3 Risk Assessment
    - 7.2 Conclusions
        - 7.2.1 Data Limitations and Recommendations for Future Work
        - 7.2.2 Recommended Remedial Action Objectives

Appendices
A. Technical Memoranda on Field Activities (if available)
B. Analytical Data and QA/QC Evaluation Results
C. Risk Assessment Methods

CHAPTER 4

DEVELOPMENT AND SCREENING OF ALTERNATIVES


SITE CHARACTERIZATION
TREATABILITY INVESTIGATION
FROM:
● Preliminary Assessment
● Site Inspection
● NPL Listing
SCOPING OF THE RI/FS
DEVELOPMENT AND SCREENING OF ALTERNATIVES
DETAILED ANALYSIS OF ALTERNATIVES
TO:
● Remedy Selection
● Record of Decision
● Remedial Design
● Remedial Action
DEVELOPMENT AND SCREENING OF ALTERNATIVES
● Identify Potential Treatment Technologies Containment/ Disposal Requirements for Residuals or Untreated Waste
● Screen Technologies
● Identify Action-Specific ARARs
● Assemble Technologies into Alternatives
● Screen Alternatives as Necessary

Chapter 4

Development and Screening of Alternatives

4.1 Introduction

4.1.1 Purpose of Alternative Development and Screening

The primary objective of this phase of the FS is to develop an appropriate range of waste management options that will be analyzed more fully in the detailed analysis phase of the FS. Appropriate waste management options that ensure the protection of human health and the environment may involve, depending on site-specific circumstances, the complete elimination or destruction of hazardous substances at the site, the reduction of concentrations of hazardous substances to acceptable health-based levels, and prevention of exposure to hazardous substances via engineering or institutional controls, or some combination of the above. Alternatives are typically developed concurrently with the RI site characterization, with the results of one influencing the other in an iterative fashion (i.e., RI site characterization data are used to develop alternatives and screen technologies, whereas the range of alternatives developed guides subsequent site characterization and/or treatability studies). An overview of the entire FS process is presented in the following subsections.

4.1.2 FS Process Overview

The FS may be viewed (for explanatory purposes) as occurring in three phases: the development of alternatives, the screening of the alternatives, and the detailed analysis of alternatives. However, in actual practice the specific point at which the first phase ends and the second begins is not so distinct. Therefore, the development and screening of alternatives are discussed together to better reflect the interrelatedness of these efforts. Furthermore, in those instances in which circumstances limit the number of available options, and therefore the number of alternatives that are developed, it may not be necessary to screen alternatives prior to the detailed analysis.

4.1.2.1 Development and Screening of Alternatives

Alternatives for remediation are developed by assembling combinations of technologies, and the media to which they would be applied, into alternatives that address contamination on a sitewide basis or for an identified operable unit. This process consists of six general steps, which are shown in Figure 4-1 and briefly discussed below:

- Develop remedial action objectives specifying the contaminants and media of interest, exposure pathways, and preliminary remediation goals that permit a range of treatment and containment alternatives to be developed. The preliminary remediation goals are developed on the basis of chemical-specific ARARs, when available, other available information (e.g., Rfds), and site-specific risk-related factors.[1]
- Develop general response actions for each medium of interest defining containment, treatment, excavation, pumping, or other actions, singly or in combination, that may be taken to satisfy the remedial action objectives for the site.
- Identify volumes or areas of media to which general response actions might be applied, taking into account the requirements for protectiveness as identified in the remedial action objectives and the chemical and physical characterization of the site.
- Identify and screen the technologies applicable to each general response action to eliminate those that cannot be implemented technically at the site.[2] The general response actions are further

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[1] These preliminary remediation goals are reevaluated as site characterization data and information from the baseline risk assessment become available.

[2] It is important to distinguish between this medium-specific *technology screening* step during development of alternatives and the *alternative screening* that may be conducted subsequently to reduce the number of alternatives prior to the detailed analysis.

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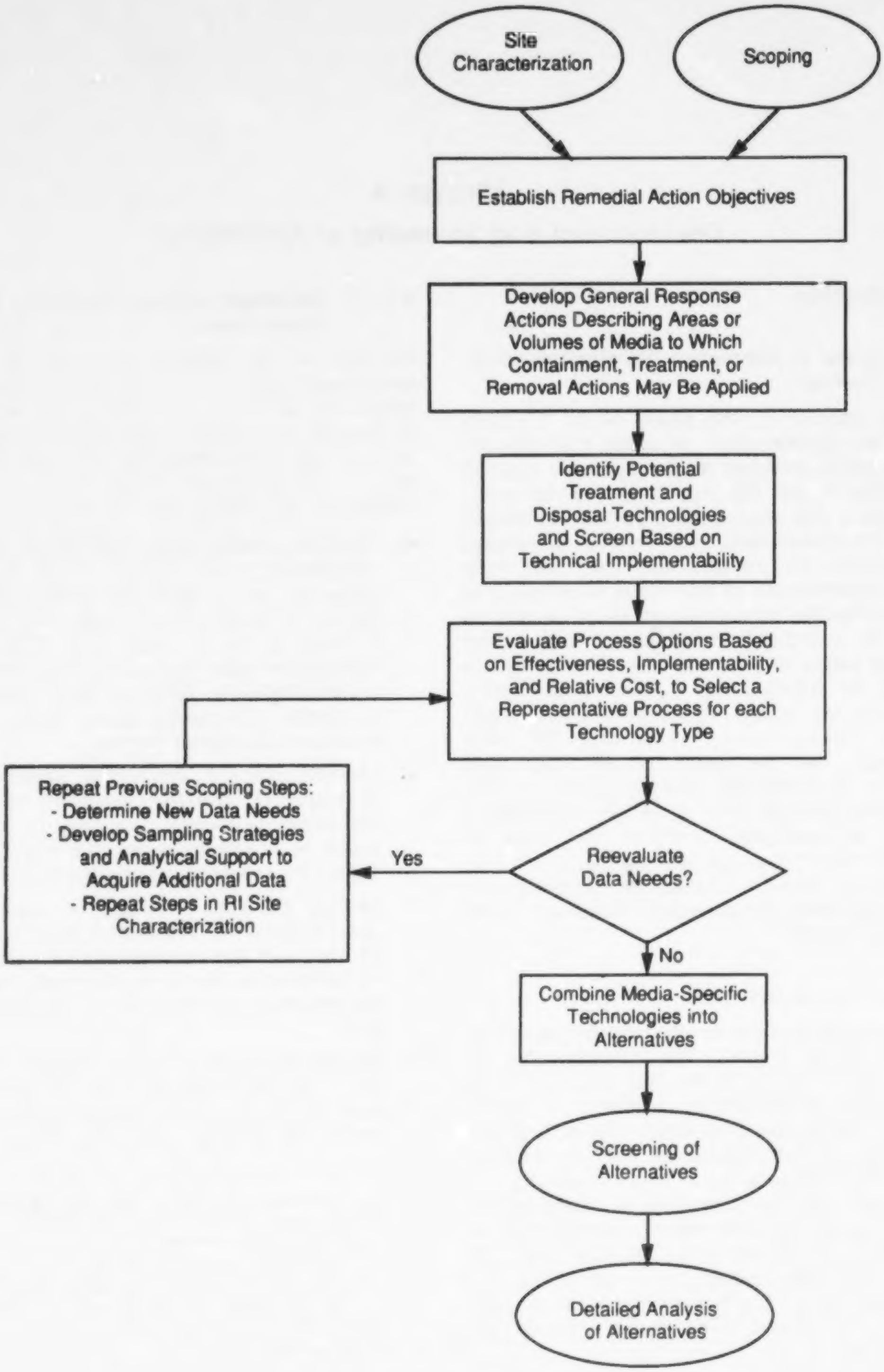
Site Characterization
Scoping
Establish Remedial Action Objectives
Develop General Response Actions Describing Areas or Volumes of Media to Which Containment, Treatment, or Removal Actions May Be Applied
Identify Potential Treatment and Disposal Technologies and Screen Based on Technical Implementability
Evaluate Process Options Based on Effectiveness, Implementability, and Relative Cost, to Select a Representative Process for each Technology Type
Repeat Previous Scoping Steps:
- Determine New Data Needs
- Develop Sampling Strategies and Analytical Support to Acquire Additional Data
- Repeat Steps in RI Site Characterization
Yes
Reevaluate Data Needs?
No
Combine Media-Specific Technologies into Alternatives
Screening of Alternatives
Detailed Analysis of Alternatives

Figure 4-1 **Alternative development.**

defined to specify remedial technology types (e.g., the general response action of treatment can be further defined to include chemical or biological technology types).

- Identify and evaluate technology process options to select a representative process for each technology type retained for consideration. Although specific processes are selected for alternative development and evaluation, these processes are intended to represent the broader range of process options within a general technology type.
- Assemble the selected representative technologies into alternatives representing a range of treatment and containment combinations, as appropriate.

Figure 4-2 provides a generic representation of this process. Section 4.2 contains a more detailed description and specific examples of alternative development.

For those situations in which numerous waste management options are appropriate and developed, the assembled alternatives may need to be refined and screened to reduce the number of alternatives that will be analyzed in detail. This screening aids in streamlining the feasibility study process while ensuring that the most promising alternatives are being considered.

As discussed earlier, in other situations the number of viable or appropriate alternatives for addressing site problems may be limited; thus, the screening effort may be minimized or eliminated if unnecessary. The scope of this screening effort can vary substantially depending on the number and type of alternatives developed and the extent of information necessary for conducting the detailed analysis. The scope and emphasis can also vary depending on either the degree to which the assembled alternatives address the combined threats posed by the entire site or on the individual threats posed by separate site areas or contaminated media. Whatever the scope, the range of treatment and containment alternatives initially developed should be preserved through the alternative screening process to the extent that it makes sense to do so.

As part of the screening process, alternatives are analyzed to investigate interactions among media in terms of both the evaluation of technologies (i.e., the extent to which source control influences the degree of ground-water or air-quality control) and sitewide protectiveness (i.e., whether the alternative provides sufficient reduction of risk from each media and/or pathway of concern for the site or that part of the site being addressed by an operable unit). Also at this stage, the areas and quantities of contaminated media initially specified in the general response actions may also be reevaluated with respect to the effects of interactions between media. Often, source control actions influence the degree to which ground-water remediation can be accomplished or the time frame in which it can be achieved. In such instances, further analyses may be conducted to modify either the source control or ground-water response actions to achieve greater effectiveness in sitewide alternatives. Using these refined alternative configurations, more detailed information about the technology process options may be developed. This information might include data on the size and capacities of treatment systems, the quantity of materials required for construction, and the configuration and design requirements for ground-water collection systems.

Information available at the time of screening should be used primarily to identify and distinguish any differences among the various alternatives and to evaluate each alternative with respect to its effectiveness, implementability, and cost. Only the alternatives judged as the best or most promising on the basis of these evaluation factors should be retained for further consideration and analysis.[3] Typically, those alternatives that are screened out will receive no further consideration unless additional information becomes available that indicates further evaluation is warranted. As discussed in Section 4.2.6, for sites at which interactions among media are not significant, the process of screening alternatives, described here, may be applied to medium-specific options to reduce the number of options that will either be combined into sitewide alternatives at the conclusion of screening or will await further evaluation in the detailed analyses. Section 4.3 contains more detail about screening alternatives.

4.1.2.2 Detailed Analysis of Alternatives

During the detailed analysis, the alternatives brought through screening are further refined, as appropriate, and analyzed in detail with respect to the evaluation criteria described in Chapter 6. Alternatives may be further refined and/or modified based on additional site characterization or treatability studies conducted as part of the RI. The detailed analysis should be conducted so that decision-makers are provided with sufficient information to compare alternatives with respect to the evaluation criteria and to select an appropriate remedy. Analysis activities are described in greater detail in Chapter 6.

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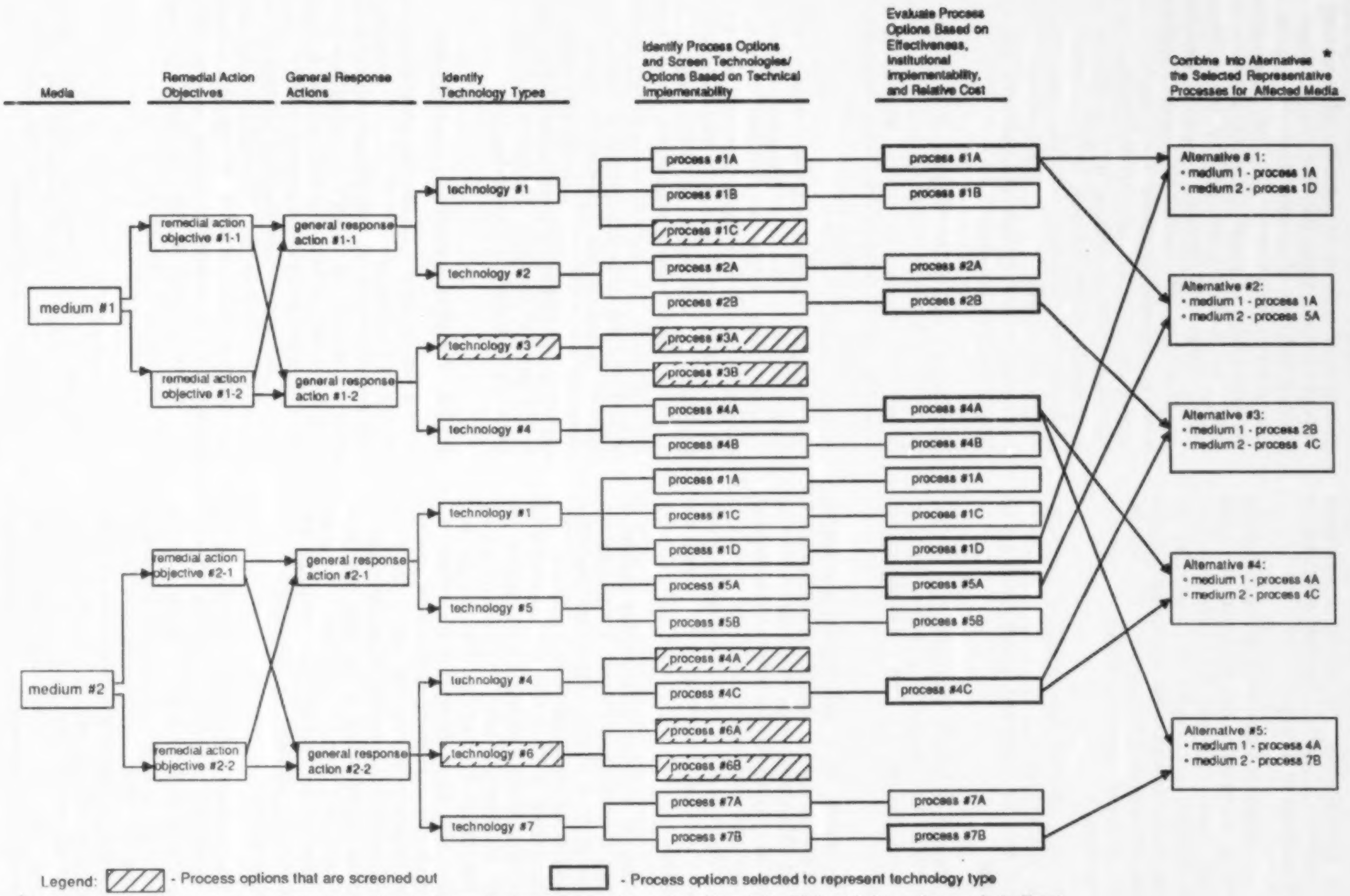
[3] As with the use of representative technologies, alternatives may be selected to represent sufficiently similar management strategies; thus, in effect, a separate analysis for each alternative is not always warranted.


Media
Remedial Action Objectives
General Response Actions
Identify Technology Types
Identify Process Options and Screen Technologies/ Options Based on Technical Implementability
Evaluate Process Options Based on Effectiveness, Institutional Implementability, and Relative Cost
Combine Into Alternatives the Selected Representative Processes for Affected Media *
medium #1
medium #2
remedial action objective #1-1
remedial action objective #1-2
remedial action objective #2-1
remedial action objective #2-2
general response action #1-1
general response action #1-2
general response action #2-1
general response action #2-2
technology #1
technology #2
technology #3
technology #4
technology #1
technology #5
technology #4
technology #6
technology #7
process #1A
process #1B
process #1C
process #2A
process #2B
process #3A
process #3B
process #4A
process #4B
process #1A
process #1C
process #1D
process #5A
process #5B
process #4A
process #4C
process #6A
process #6B
process #7A
process #7B
Alternative # 1:
• medium 1 - process 1A
• medium 2 - process 1D
Alternative #2:
• medium 1 - process 1A
• medium 2 - process 5A
Alternative #3:
• medium 1 - process 2B
• medium 2 - process 4C
Alternative #4:
• medium 1 - process 4A
• medium 2 - process 4C
Alternative #5:
• medium 1 - process 4A
• medium 2 - process 7B
Legend: ▨ - Process options that are screened out
☐ - Process options selected to represent technology type

* Note: The combination of medium-technology options into sitewide alternatives may be conducted later in the FS if media interactions are insignificant.

Figure 4-2. **Generic alternative development process.**

4.1.3 Alternative Ranges

Alternatives should be developed that will provide decision-makers with an appropriate range of options and sufficient information to adequately compare alternatives against one another. In developing alternatives, the range of options will vary depending on site-specific conditions. A general description of ranges for source control and ground-water response actions that should be developed, as appropriate, are described below.

4.1.3.1 Source Control Actions

For source control actions, the following types of alternatives should be developed to the extent practicable:

- A number of treatment alternatives ranging from one that would eliminate or minimize to the extent feasible the need for long-term management (including monitoring) at a site to one that would use treatment as a primary component of an alternative to address the principal threats at the site.[4] Alternatives within this range typically will differ in the type and extent of treatment used and the management requirements of treatment residuals or untreated wastes.
- One or more alternatives that involve containment of waste with little or no treatment but protect human health and the environment by preventing potential exposure and/or reducing the mobility of contaminants.
- A no-action alternative[5]

Figure 4-3 conceptually illustrates this range for source control alternatives.

Development of a complete range of treatment alternatives will not be practical in some situations. For example, for sites with large volumes of low concentrated wastes such as some municipal landfills and mining sites, an alternative that eliminates the need for long-term management may not be reasonable given site conditions, the limitations of technologies, and extreme costs that may be involved. If a full range of alternatives is not developed, the specific reasons for doing so should be briefly discussed in the FS report to serve as documentation that treatment alternatives were assessed as required by CERCLA.

4.1.3.2 Ground-water Response Actions

For ground-water response actions, alternatives should address not only cleanup levels but also the time frame within which the alternatives might be achieved. Depending on specific site conditions and the aquifer characteristics, alternatives should be developed that achieve ARARs or other health-based levels determined to be protective within varying time frames using different methodologies. For aquifers currently being used as a drinking water source, alternatives should be configured that would achieve ARARs or risk-based levels as rapidly as possible. More detailed information on developing remedial alternatives for ground-water response actions may be found in "Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites" (U.S. EPA, August 1988).

4.2 Alternative Development Process

The alternative development process may be viewed as consisting of a series of analytical steps that involves making successively more specific definitions of potential remedial activities. These steps are described in the following sections.

4.2.1 Develop Remedial Action Objectives

Remedial action objectives consist of medium-specific or operable unit-specific goals for protecting human health and the environment. The objectives should be as specific as possible but not so specific that the range of alternatives that can be developed is unduly limited. Column two of Table 4-1 provides examples of remedial action objectives for various media.

Remedial action objectives aimed at protecting human health and the environment should specify:

- The contaminant(s) of concern
- Exposure route(s) and receptor(s)
- An acceptable contaminant level or range of levels for each exposure route (i.e., a preliminary remediation goal)

Remedial action objectives for protecting human receptors should express both a contaminant level and an exposure route, rather than contaminant levels alone, because protectiveness may be achieved by reducing exposure (such as capping an area, limiting access, or providing an alternate water supply) as well as by reducing contaminant levels. Because

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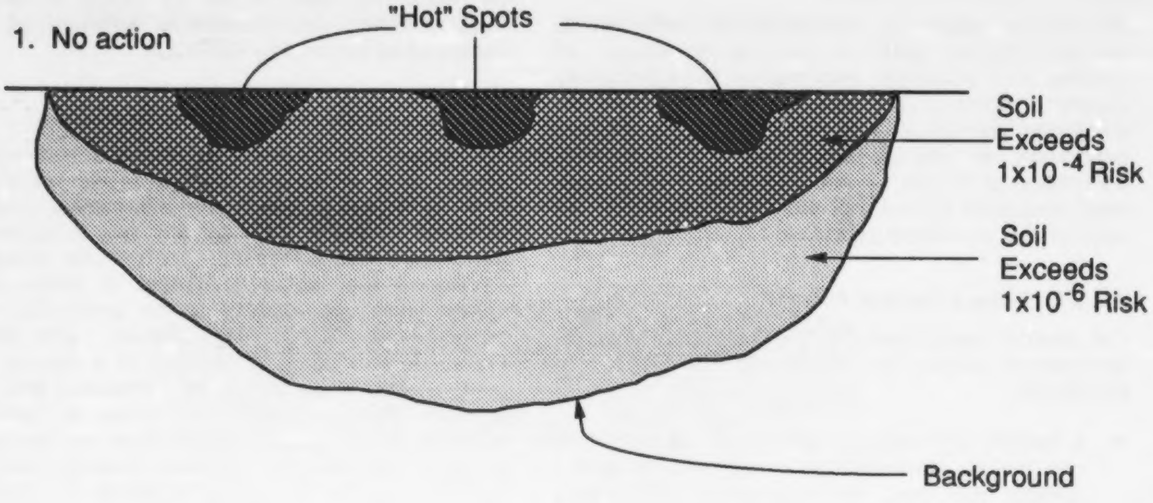
[4] Alternatives for which treatment is a principal element could include containment elements for untreated waste or treatment residuals as well.

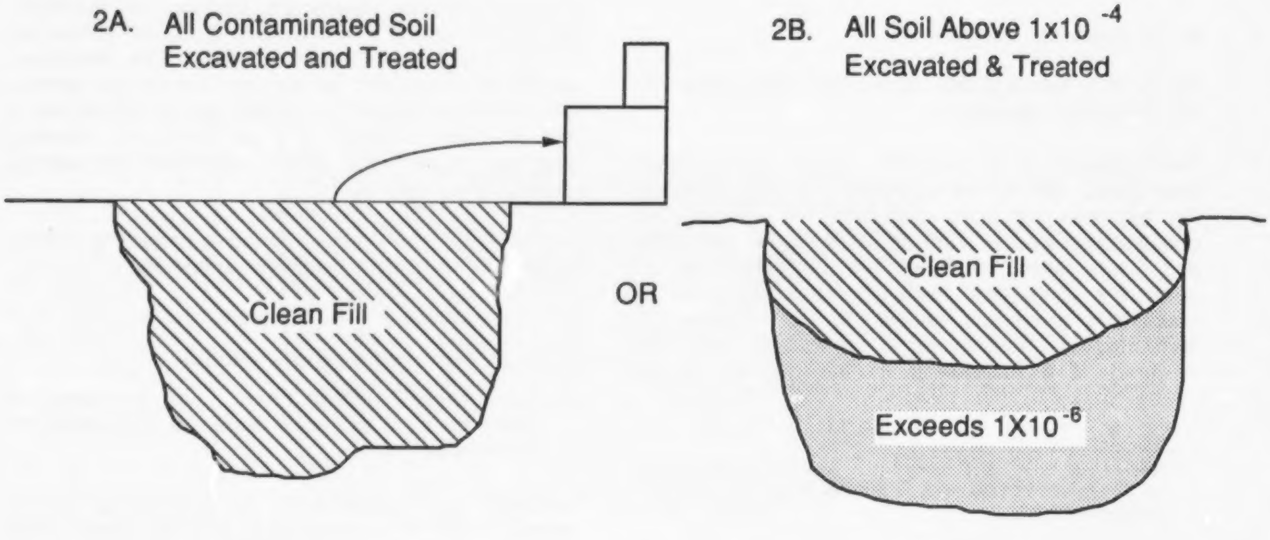
[5] Although a no-action alternative may include some type of environmental monitoring, actions taken to reduce the potential for exposure (e.g., site fencing, deed restrictions) should not be included as a component of the no-action alternatives. Such minimal actions should constitute a separate "limited" action alternative.



1. No action

"Hot" Spots
Soil Exceeds 1×10^{-4} Risk
Soil Exceeds 1×10^{-6} Risk
Background

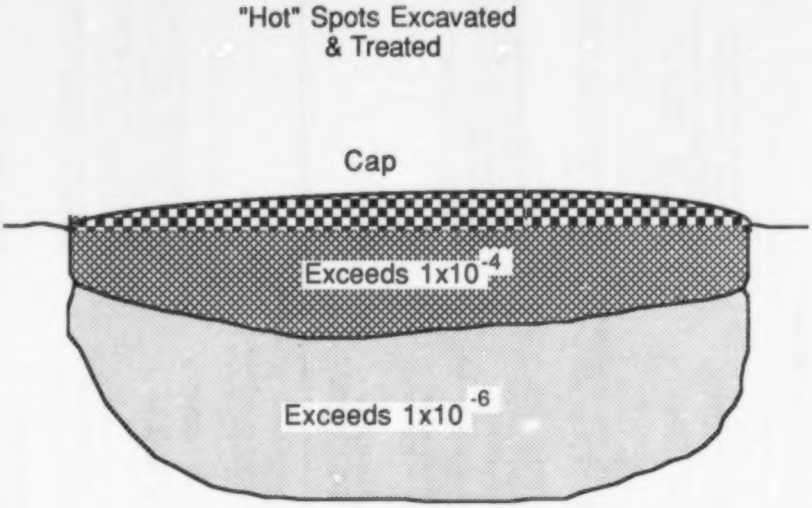
2. Treatment which eliminates or minimizes to the extent feasible the need for long-term management.



2A. All Contaminated Soil Excavated and Treated
Clean Fill
OR
2B. All Soil Above 1×10^{-4} Excavated & Treated
Clean Fill
Exceeds 1×10^{-6}

Figure 4-3 Conceptual treatment range for source control.

3. Alternatives using treatment as a principal element


"Hot" Spots Excavated
& Treated
Cap
Exceeds $1x10^{-4}$
Exceeds $1x10^{-6}$

4. Containment with little or no treatment

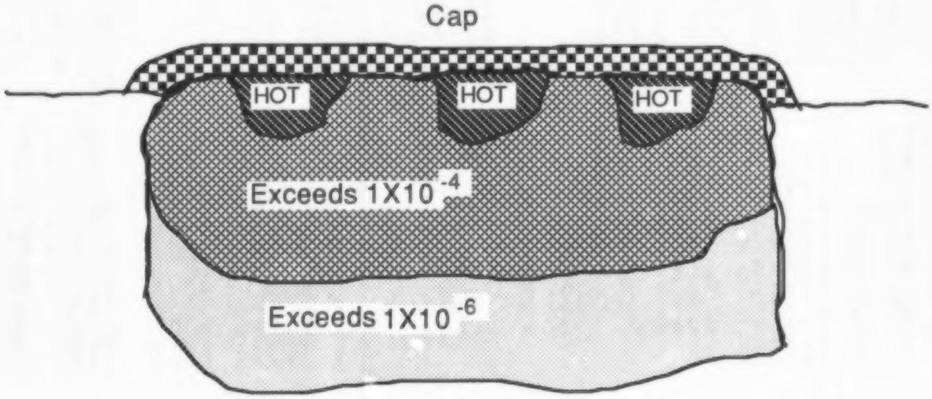

Cap
HOT
HOT
HOT
Exceeds $1X10^{-4}$
Exceeds $1X10^{-6}$

Figure 4-3 (Continued)

Table 4-1. Example of Remedial Action Objectives, General Response Actions, Technology Types, and Example Process Options for the Development and Screening of Technologies

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Actions (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Ground Water	For Human Health:	No Action/Institutional Actions: No action Alternative residential water supply Monitoring	No Action/Institutional Options: Fencing Deed restrictions	
	Prevent ingestion of water having [carcinogen(s)] in excess of [MCL(s)] and a total excess cancer risk (for all contaminants) of greater than 10^{-4} to 10^{-7}.	Containment Actions: Containment	Containment Technologies: Capping Vertical barriers Horizontal barriers	 Clay cap, synthetic membrane, multi-layer Slurry wall, sheet piling Liners, grout injection
	Prevent ingestion of water having [non-carcinogen(s)] in excess of [MCL)s)] or [reference dose(s)].	Collection/Treatment Actions: Collection/treatment discharge/ in situ groundwater treatment Individual home treatment units	Extraction Technologies: Ground water collection/pumping Enhanced removal	 Wells, subsurface or leachate collection Solution mining, vapor extraction, enhanced oil recovery
	For Environmental Protection: Restore ground water aquifer to [concentration(s)] for [contaminant(s)].		Treatment Technologies: Physical treatment Chemical treatment In situ treatment	 Coagulation/flocculation, oil-water separation, air stripping, adsorption Neutralization, precipitation, ion exchange oxidation/reduction Subsurface bioreclamation
			Disposal Technologies: Discharge to POTW (after treatment) Discharge to surface water (after treatment)	
Soil	For Human Health: Prevent ingestion/direct contact with soil having [non-carcinogen(s)] in excess of [reference dose(s)].	No Action/Institutional Actions: No action Access restrictions	No Action/Institutional Options: Fencing Deed restrictions	
	Prevent direct contact/ingestion with soil having 10^{-4} to 10^{-7} excess cancer risk from [carcinogen(s)].	Containment Actions: Containment	Containment Technologies: Capping Vertical barriers Horizontal barriers Surface controls	 Clay cap, synthetic membrane, multi-layer Slurry wall, sheet piling Liners, grout injection Diversion/collection, grading, soil stabilization
			Sediment control barriers Dust controls	Coffer dams, curtain barriers Revegetation, capping
	Prevent inhalation of [carcinogen(s)] posing excess cancer risk levels of 10^{-4} to 10^{-7}.	Excavation/Treatment Actions: Excavation/treatment/disposal In situ treatment Disposal excavation	Removal Technologies: Excavation	 Solids excavation
	For Environmental Protection: Prevent migration of contaminants that would result in ground water contamination in excess of [concentration(s)] for [contaminant(s)].		Treatment Technologies: Solidification, fixation, stabilization, immobilization Dewatering Physical treatment Chemical treatment Biological treatment In situ treatment Thermal treatment	 Sorption, pozzolanic agents, encapsulation Belt filter press, dewatering, and drying beds Water/solvent leaching (with subsequent liquids treatment) Lime neutralization Cultured micro-organisms Surface bioreclamation Incineration, pyrolysis

Table 4-1. Continued

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Actions (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Surface Water	For Human Health: Prevent ingestion of water having [carcinogen(s)] in excess of [MCLs] and a total excess cancer risk of greater than 10^{-4} to 10^{-7}. Prevent ingestion of water having [non-carcinogen(s)] in excess of [MCLs] or [reference dose(s)]. For Environmental Protection: Restore surface water to [ambient water quality criteria] for [contaminant(s)].	No Action/Institutional Actions: No action Access restrictions Monitoring Collection/Treatment Actions: Surface water runoff interception/ treatment/discharge	No Action/Institutional Options: Fencing Deed restrictions	
			Collection Technologies: Surface controls	Grading, diversion, and collection
			Treatment Technologies: Physical treatment	Coagulation/flocculation, oil-water separation, filtration, adsorption
			Chemical treatment	Precipitation, ion exchange, neutralization, freeze crystallization biological treatment,
			Biological treatment (organics)	Aerobic and anaerobic spray irrigation
			In situ treatment	In situ precipitation, in situ bioreclamation
			Disposal Technologies: Discharge to POTW (after treatment)	
Sediment	For Human Health: Prevent direct contact with sediment having [carcinogen(s)] in excess of 10^{-4} to 10^{-7} excess cancer risk. For Environmental Protection: Prevent releases of [contaminant(s)] from sediments that would result in surface water levels in excess of [ambient water quality criteria].	No Action/Institutional Actions: No action Access restrictions to Monitoring Excavation Actions: Excavation Excavation/Treatment Actions: Removal/disposal Removal/treatment/disposal	No Action/Institutional Options: Fencing Deed restrictions	
			Removal Technologies: Excavation	Sediments excavation
			Containment Technologies: Capping	Removal with clay cap, multi-layer, asphalt
			Vertical barriers	Slurry wall, sheet piling
			Horizontal barriers	Liners, grout injection
			Sediment control barriers	Coffer dams, curtain barriers, capping barriers
			Treatment Technologies: Solidification, fixation, stabilization	Sorption, pozzolanic agents, encapsulation
			Dewatering	Sedimentation, dewatering and drying beds
			Physical treatment	Water/solids leaching (with subsequent treatment)
			Chemical treatment	Neutralization, oxidation, electrochemical reduction
			Biological treatment	Landfarming
			In situ treatment	Surface bioreclamation
			Thermal treatment	Incineration, pyrolysis
Air	For Human Health: Prevent inhalation of [carcinogen(s)] in excess of 10^{-4} to 10^{-7} excess cancer risk.	No Action/Institutional Actions: No action Access restrictions to Monitoring Collection Actions: Gas collection	No Action/Institutional Options: Fencing Deed restrictions	
			Removal Technologies: Landfill gas collection	Passive vents, active gas collection systems

Table 4-1. Continued

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Actions (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Structures	For Human Health: Prevent direct contact with [carcinogen(s)] in excess of 10^{-4} to 10^{-7} excess cancer risk. Prevent migration of [carcinogen(s)] which would result in ground water concentrations in excess of [MCLs] or 10^{-4} to 10^{-7} total excess cancer risk level. Prevent migration of [carcinogen(s)] which would result in soil concentrations in excess of [reference dose(s)]. For Environmental Protection: Prevent migration of [contaminants] that would result in ground water concentrations in excess of [concentration(s)].	No Action/Institutional Actions: No action Access restrictions Demolition/Treatment Actions: Demolition/disposal Decontamination	No Action/Institutional Options: Fencing Deed restrictions Removal Technologies: Demolition Excavation Treatment Technologies: Solids processing Solids treatment	Demolition Excavation, debris removal Magnetic processes, crushing and grinding, screening Water leaching, solvent leaching, steam cleaning
Solid Wastes	For Human Health: Prevent ingestion/direct contact with wastes having [non-carcinogen(s)] in excess of [reference dose(s)]. Prevent ingestion/direct contact with wastes having 10^{-4} to 10^{-7} excess cancer risk from [carcinogen(s)]. Prevent inhalation of [carcinogen(s)] posing excess cancer risk levels of 10^{-4} to 10^{-7}. Prevent migration of [carcinogen(s)] which would result in ground water concentrations in excess of [MCLs] or 10^{-4} to 10^{-7} total excess cancer risk levels.	No Action/Institutional Actions: No action Access restrictions to [location] Containment Actions: Containment Excavation/Treatment Actions: Removal/disposal Removal/treatment/disposal	No Action/Institutional Options: Fencing Deed restrictions Containment Technologies: Capping Vertical barriers Horizontal barriers Removal Technologies: Excavation Drum removal Treatment Technologies: Physical treatment Chemical treatment Biological treatment Thermal treatment Solids processing	Clay cap, synthetic membranes, multi-layer Slurry wall, sheet piling Liners, grout injection Dust controls Solids excavation Drum and debris removal Water/solvent leaching (with subsequent liquids treatment) Neutralization Cultured micro-organisms Incineration, pyrolysis, gaseous incineration Crushing and grinding, screening, classification

Table 4-1. Continued

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Actions (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Solid Wastes (continued)	For Environmental Protection: Prevent migration of contaminants that would result in ground water contamination in excess of [concentration(s)] for [contaminant(s)].			
Liquid Wastes	For Human Health: Prevent ingestion/direct contact with wastes having [non-carcinogen(s)] in excess of [reference dose(s)].	No Action/Institutional Actions: No action Access restrictions to [location]	No Action/Institutional Options: Fencing Deed restrictions	
	Prevent ingestion/direct contact with wastes having 10^{-4} to 10^{-7} excess cancer risk from [carcinogen(s)].	Containment Actions: Containment	Containment Technologies: Vertical barriers Horizontal barriers	Slurry wall Liners
	Prevent inhalation of [carcinogen(s)] posing excess cancer risk levels of 10^{-4} to 10^{-7}.	Removal/Treatment Actions: Removal/disposal	Removal Technologies: Bulk liquid removal Drum removal	Bulk liquid removal Drum removal
	Prevent migration of [carcinogen(s)] which would result in groundwater concentrations in excess of [MCLs] or 10^{-4} to 10^{-7} total excess cancer risk levels.	Removal/treatment/disposal	Treatment Technologies: Physical treatment	Coagulation/flocculation, adsorption, evaporation, distillation
			Chemical treatment	Neutralization, oxidation, reduction, photolysis
	For Environmental Protection: Prevent migration of contaminants that would result in groundwater contamination in excess of [concentration(s)] for [contaminant(s)].		Biological treatment	Aerobic/anaerobic biological treatment, biotechnologies
			Thermal treatment (organics)	Incineration, pyrolysis, co-disposal
			Disposal Technologies: Product reuse Discharge to POTW (after treatment)	
Sludges	For Human Health: Prevent direct contact with sludge having [carcinogen(s)] in excess of 10^{-4} to 10^{-7} excess cancer risk.	No Action/Institutional Actions: No action Access restrictions to [location]	No Action/Institutional Options: Fencing Deed restrictions	
	Prevent ingestion/contact with sludge having [non-carcinogen(s)] in excess of [reference dose(s)].	Containment Actions: Containment	Containment Technologies: Vertical barriers Horizontal barriers	Slurry wall, sheet piling Liners
		Removal/Treatment Actions: Removal/disposal	Removal Technologies: Bulk sludge removal Drum removal	Semi-solid excavation, pumping Drum removal
			Treatment Technologies: Solidification, fixation	Sorption, pozzolanic agents, encapsulation

Table 4-1. Continued

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Actions (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Sludges (continued)	Prevent migration of [carcinogen(s)] which would result in ground water concentrations in excess of 10^{-4} to 10^{-7} excess cancer risk. For Environmental Protection: Prevent releases of [contaminant(s)] from sludge that would result in surface water levels in excess of [ambient water quality criteria]. Prevent releases of [contaminant(s)] from sludge that would result in ground water levels of [contaminant(s)] in excess of [concentration(s)].	Removal/treatment/disposal	Physical treatment	Freeze crystallization, neutralization, oxidation, electrochemical reduction
			Chemical treatment	Oxidation, reduction, photolysis
			Biological treatment	Aerobic/anaerobic treatment, land treatment new biotechnologies
			Thermal treatment (organics)	Incineration, pyrolysis, co-disposal
			Dewatering	Gravity thickening, belt filter press, vacuum filtration
			Disposal Technologies:	
			Product reuse	
			Landfilling (after treatment)	

remedial action objectives for protecting environmental receptors typically seek to preserve or restore a resource (e.g., as ground water), environmental objective(s) should be expressed in terms of the medium of interest and target cleanup levels, whenever possible.

Although the preliminary remediation goals are established on readily available information [e.g., reference doses (Rfds) and risk-specific doses (RSDs)] or frequently used standards (e.g., ARARs), the final acceptable exposure levels should be determined on the basis of the results of the baseline risk assessment and the evaluation of the expected exposures and associated risks for each alternative. Contaminant levels in each media should be compared with these acceptable levels and include an evaluation of the following factors:

- Whether the remediation goals for all carcinogens of concern, including those with goals set at the chemical-specific ARAR level, provides protection within the risk range of 10^{-4} to 10^{-7}.
- Whether the remediation goals set for all non-carcinogens of concern, including those with goals set at the chemical-specific ARAR level, are sufficiently protective at the site.
- Whether environmental effects (in addition to human health effects) are adequately addressed.
- Whether the exposure analysis conducted as part of the risk assessment adequately addresses each significant pathway of human exposure identified in the baseline risk assessment. For example, if the exposure from the ingestion of fish and drinking water are both significant pathways of exposure, goals set by considering only one of these exposure pathways may not be adequately protective. The SPHEM provides additional details on establishing acceptable exposure levels.

4.2.2 Develop General Response Actions

General response actions describe those actions that will satisfy the remedial action objectives. General response actions may include treatment, containment, excavation, extraction, disposal, institutional actions, or a combination of these. Like remedial action objectives, general response actions are medium-specific.

General response actions that might be used at a site are initially defined during scoping and are refined throughout the RI/FS as a better understanding of site conditions is gained and action-specific ARARs are identified. In developing alternatives, combinations of general response actions may be identified, particularly when disposal methods primarily depend on whether the medium has been previously treated. Examples of potential general response actions are included in column three of Table 4-1.

4.2.3 Identify Volumes or Areas of Media

During the development of alternatives an initial determination is made of areas or volumes of media to which general response actions might be applied. This initial determination is made for each medium of interest at a site. To take interactions between media into account, response actions for areas or volumes of media are often refined after sitewide alternatives have been assembled. The refinement of alternatives is discussed at greater length in Section 4.3.1.

Defining the areas or volumes of media requires careful judgment and should include a consideration of not only acceptable exposure levels and potential exposure routes, but also site conditions and the nature and extent of contamination. For example, in an area with contamination that is homogeneously distributed in a medium, discrete risk levels (e.g., 10^{-5}, 10^{-6}) or corresponding contaminant levels may provide the most rational basis for defining areas or volumes of media to which treatment, containment, or excavation actions may be applied. For sites with discrete hot spots or areas of more concentrated contamination, however, it may be more useful to define areas and volumes for remediation on the basis of the site-specific relationship of volume (or area) to contaminant level. Therefore, when areas or volumes of media are defined on the basis of site-specific considerations such as volume versus concentration relationships, the volume or area addressed by the alternative should be reviewed with respect to the remedial action objectives to ensure that alternatives can be assembled to reduce exposure to protective levels.

4.2.4 Identify and Screen Remedial Technologies and Process Options

In this step, the universe of potentially applicable technology types and process options is reduced by evaluating the options with respect to technical implementability. In this guidance document, the term "technology types" refers to general categories of technologies, such as chemical treatment, thermal destruction, immobilization, capping, or dewatering. The term "technology process options" refers to specific processes within each technology type. For example, the chemical treatment technology type would include such process options as precipitation, ion exchange, and oxidation/reduction. As shown in columns four and five of Table 4-1, several broad technology types may be identified for each general response action, and numerous technology process options may exist within each technology type.

Technology types and process options may be identified by drawing on a variety of sources including references developed for application to Superfund sites and more standard engineering texts not specifically directed toward hazardous waste sites. Some of these sources are included in Appendix D of this document.

During this screening step, process options and entire technology types are eliminated from further consideration on the basis of technical implementability. This is accomplished by using readily available information from the RI site characterization on contaminant types and concentrations and onsite characteristics to screen out technologies and process options that cannot be effectively implemented at the site.

Two factors that commonly influence technology screening are the presence of inorganic contaminants, which limit the applicability of many types of treatment processes, and the subsurface conditions, such as depth to impervious formations or the degree of fracture in bedrock, which can limit many types of containment and ground-water collection technologies. This screening step is site-specific, however, and other factors may need to be considered. Figure 4-4 provides an example of initial technology screening for ground-water remediation at a site having organic and inorganic contaminants and shallow, fractured bedrock.

As with all decisions during an RI/FS, the screening of technologies should be documented. For most studies, a figure similar to Figure 4-4 provides adequate information for this purpose and can be included in the FS report.

4.2.5 Evaluate Process Options

In the fourth step of alternative development, the technology processes considered to be implementable are evaluated in greater detail before selecting one process to represent each technology type. One representative process is selected, if possible, for each technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design. The representative process provides a basis for developing performance specifications during preliminary design; however, the specific process actually used to implement the remedial action at a site may not be selected until the remedial design phase. In some cases more than one process option may be selected for a technology type. This may be done if two or more processes are sufficiently different in their performance that one would not adequately represent the other.

Process options are evaluated using the same criteria - effectiveness, implementability, and cost - that are used to screen alternatives prior to the detailed analysis. An important distinction to make is that at this time these criteria are applied only to technologies and the general response actions they are intended to satisfy and not to the site as a whole. Furthermore, the evaluation should typically focus on effectiveness factors at this stage with less effort directed at the implementability and cost evaluation.

Because of the limited data on innovative technologies, it may not be possible to evaluate these process options on the same basis as other demonstrated technologies. Typically, if innovative technologies are judged to be implementable they are retained for evaluation either as a "selected" process option (if available information indicates that they will provide better treatment, fewer or less adverse effects, or lower costs than other options), or they will be "represented" by another process option of the same technology type. The evaluation of process options is illustrated in Figure 4-5 and discussed in more detail below.

4.2.5.1 Effectiveness Evaluation

Specific technology processes that have been identified should be evaluated further on their effectiveness relative to other processes within the same technology type. This evaluation should focus on: (1) the potential effectiveness of process options in handling the estimated areas or volumes of media and meeting the remediation goals identified in the remedial action objectives;[6] (2) the potential impacts to human health and the environment during the construction and implementation phase; and (3) how proven and reliable the process is with respect to the contaminants and conditions at the site.

Information needed to evaluate the effectiveness of technology types for the different media includes contaminant type and concentration, the area or volume of contaminated media, and, when appropriate, rates of collection of liquid or gaseous media. For some media it may be necessary to conduct preliminary analyses or collect additional site data to adequately evaluate effectiveness. This is often the case for processes in which the rates of removal or collection and treatment are needed for evaluation, such as for ground-water extraction, surface-water collection and treatment, or subsurface gas collection. In such cases, a limited conceptual design of the process may need to be developed, and modeling of the potential environmental transport mechanisms associated with their operation may be undertaken. Typically, however, such analyses are conducted during the

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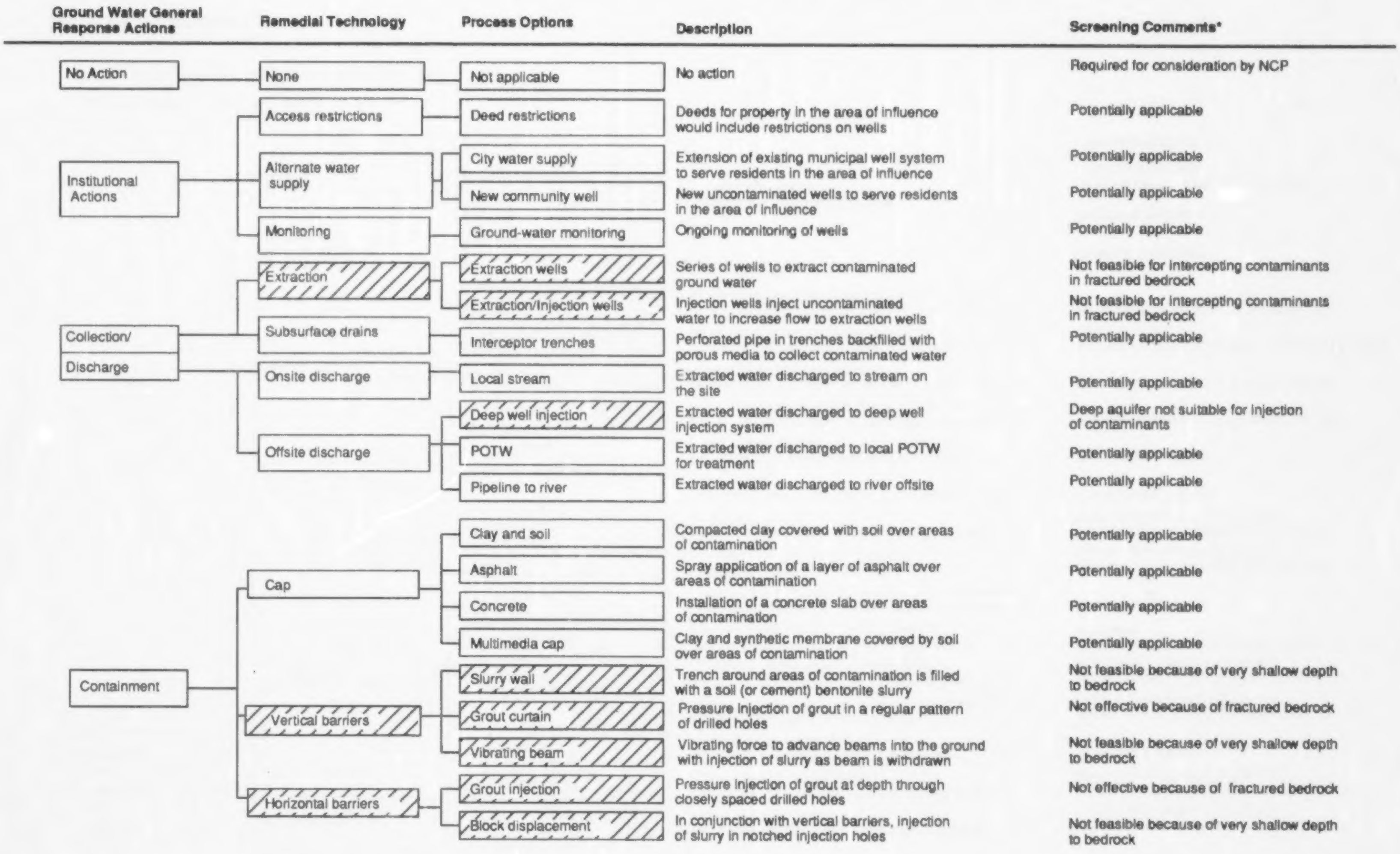
[6] The ability of some collection/removal systems, such as ground-water pumping, to sufficiently recover contaminated media for subsequent treatment may also be assessed as part of this evaluation.

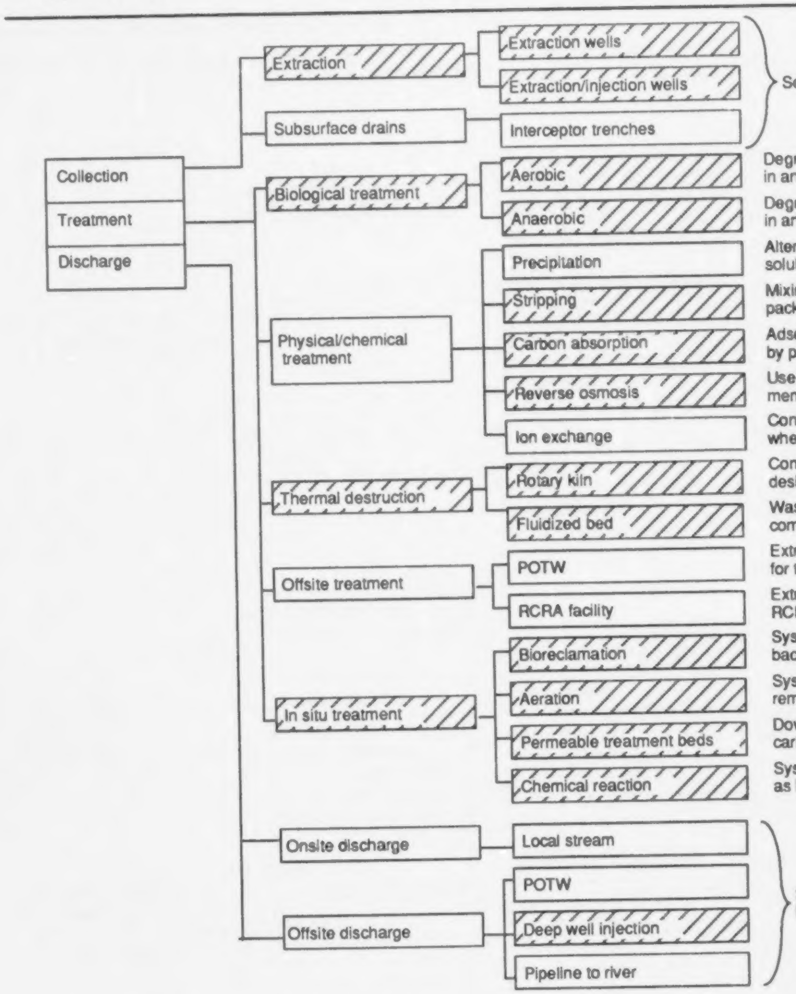


Ground Water General Response Actions	Remedial Technology	Process Options	Description	Screening Comments*
No Action	None	Not applicable	No action	Required for consideration by NCP
Institutional Actions	Access restrictions	Deed restrictions	Deeds for property in the area of influence would include restrictions on wells	Potentially applicable
	Alternate water supply	City water supply	Extension of existing municipal well system to serve residents in the area of influence	Potentially applicable
		New community well	New uncontaminated wells to serve residents in the area of influence	Potentially applicable
	Monitoring	Ground-water monitoring	Ongoing monitoring of wells	Potentially applicable
Collection/ Discharge	▨ Extraction	▨ Extraction wells	Series of wells to extract contaminated ground water	Not feasible for intercepting contaminants in fractured bedrock
		▨ Extraction/Injection wells	Injection wells inject uncontaminated water to increase flow to extraction wells	Not feasible for intercepting contaminants in fractured bedrock
	Subsurface drains	Interceptor trenches	Perforated pipe in trenches backfilled with porous media to collect contaminated water	Potentially applicable
	Onsite discharge	Local stream	Extracted water discharged to stream on the site	Potentially applicable
	Offsite discharge	▨ Deep well injection	Extracted water discharged to deep well injection system	Deep aquifer not suitable for injection of contaminants
		POTW	Extracted water discharged to local POTW for treatment	Potentially applicable
		Pipeline to river	Extracted water discharged to river offsite	Potentially applicable
Containment	Cap	Clay and soil	Compacted clay covered with soil over areas of contamination	Potentially applicable
		Asphalt	Spray application of a layer of asphalt over areas of contamination	Potentially applicable
		Concrete	Installation of a concrete slab over areas of contamination	Potentially applicable
		Multimedia cap	Clay and synthetic membrane covered by soil over areas of contamination	Potentially applicable
	▨ Vertical barriers	▨ Slurry wall	Trench around areas of contamination is filled with a soil (or cement) bentonite slurry	Not feasible because of very shallow depth to bedrock
		▨ Grout curtain	Pressure injection of grout in a regular pattern of drilled holes	Not effective because of fractured bedrock
		▨ Vibrating beam	Vibrating force to advance beams into the ground with injection of slurry as beam is withdrawn	Not feasible because of very shallow depth to bedrock
	▨ Horizontal barriers	▨ Grout injection	Pressure injection of grout at depth through closely spaced drilled holes	Not effective because of fractured bedrock
		▨ Block displacement	In conjunction with vertical barriers, injection of slurry in notched injection holes	Not feasible because of very shallow depth to bedrock

Legend ▨ - Technologies that are screened out.

* Screening comments may or may not be applicable to actual sites.

Figure 4-4. An example of initial screening of technologies and process options.

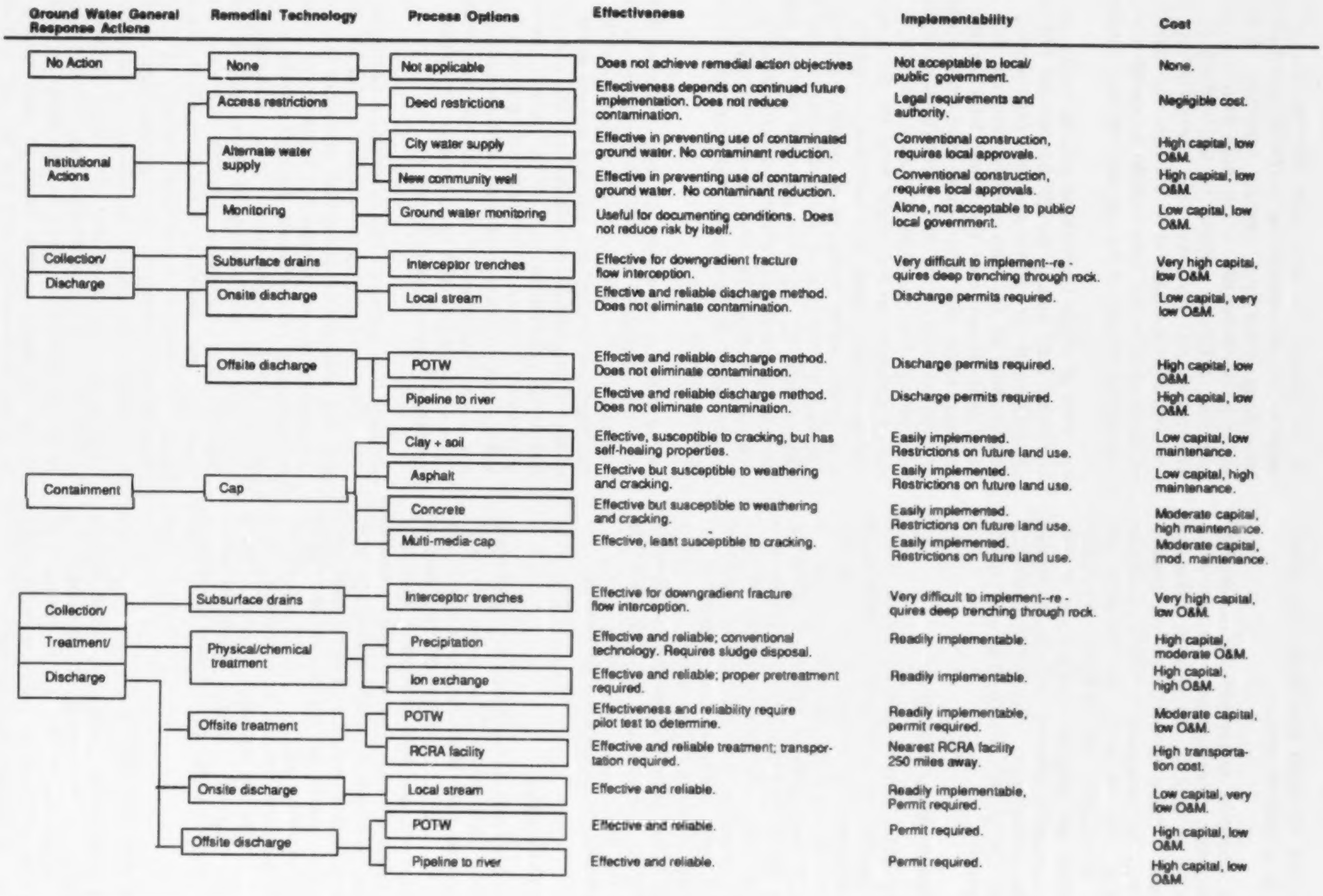


Ground Water General Response Actions	Remedial Technology	Process Options	Description	Screening Comments*
Collection	▨ Extraction	▨ Extraction wells	See "Collection/Discharge" above	Not feasible for intercepting contaminants in fractured bedrock
		▨ Extraction/injection wells		Not feasible for intercepting contaminants in fractured bedrock
	Subsurface drains	Interceptor trenches		Potentially applicable
Treatment	▨ Biological treatment	▨ Aerobic	Degradation of organics using microorganisims in an aerobic environment	Not applicable to inorganic contaminants found in ground water at the site
		▨ Anaerobic	Degradation of organics using microorganisims in an anaerobic environment	Not applicable to inorganic contaminants found in ground water at the site
	Physical/chemical treatment	Precipitation	Alteration of chemical equilibria to reduce solubility of the contaminants	Potentially applicable
		▨ Stripping	Mixing large volumes of air with water in a packed column to promote transfer of VOCs to air	Not applicable to inorganic contaminants found in ground water at the site
		▨ Carbon absorption	Adsorption of contaminants onto activated carbon by passing water through carbon column	Not applicable to inorganic contaminants found in ground water at the site
		▨ Reverse osmosis	Use of high pressure to force water through a membrane leaving contaminants behind	Contaminant concentrations too low for treatment
		Ion exchange	Contaminated water is passed through a resin bed where ions are exchanged between resin and water	Potentially applicable
	▨ Thermal destruction	▨ Rotary kiln	Combustion in a horizontally rotating cylinder designed for uniform heat transfer	Not applicable to inorganic contaminants found in ground water at the site
		▨ Fluidized bed	Waste injected into hot agitated bed of sand where combustion occurs	Not applicable to inorganic contaminants found in ground water at the site
	Offsite treatment	POTW	Extracted ground water discharged to local POTW for treatment	Potentially applicable
		RCRA facility	Extracted ground water discharged to liscensed RCRA facility for treatment and/or disposal	Potentially applicable
	▨ In situ treatment	▨ Bioreclamation	System of injection and extraction wells introduce bacteria and nutrients to degrade contamination	Not feasible because of fractured bedrock
		▨ Aeration	System of wells to inject air into ground water to remove volatiles by air stripping	Not feasible because of fractured bedrock
		▨ Permeable treatment beds	Downgradient trenches backfilled with activated carbon to remove contaminants from water	Not feasible because of shallow depth to bedrock, fractured bedrock
		▨ Chemical reaction	System of injection wells to inject oxidizer such as hydrogen peroxide to degrade contaminants	Not feasible because of fractured bedrock
Discharge	Onsite discharge	Local stream	See Discharge under "Collection/ Discharge" above	Potentially applicable
	Offsite discharge	POTW		Potentially applicable
		▨ Deep well injection		Deep aquifer not suitable for injection of contaminated water
		Pipeline to river		Potentially applicable

Legend ▨ - Technologies that are screened out.

*Screening comments may or may not be applicable to actual sites.

Figure 4-4. Continued.



Ground Water General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost
No Action	None	Not applicable	Does not achieve remedial action objectives	Not acceptable to local/ public government.	None.
Institutional Actions	Access restrictions	Deed restrictions	Effectiveness depends on continued future implementation. Does not reduce contamination.	Legal requirements and authority.	Negligible cost.
	Alternate water supply	City water supply	Effective in preventing use of contaminated ground water. No contaminant reduction.	Conventional construction, requires local approvals.	High capital, low O&M.
		New community well	Effective in preventing use of contaminated ground water. No contaminant reduction.	Conventional construction, requires local approvals.	High capital, low O&M.
	Monitoring	Ground water monitoring	Useful for documenting conditions. Does not reduce risk by itself.	Alone, not acceptable to public/ local government.	Low capital, low O&M.
Collection/ Discharge	Subsurface drains	Interceptor trenches	Effective for downgradient fracture flow interception.	Very difficult to implement--re - quires deep trenching through rock.	Very high capital, low O&M.
	Onsite discharge	Local stream	Effective and reliable discharge method. Does not eliminate contamination.	Discharge permits required.	Low capital, very low O&M.
	Offsite discharge	POTW	Effective and reliable discharge method. Does not eliminate contamination.	Discharge permits required.	High capital, low O&M.
		Pipeline to river	Effective and reliable discharge method. Does not eliminate contamination.	Discharge permits required.	High capital, low O&M.
Containment	Cap	Clay + soil	Effective, susceptible to cracking, but has self-healing properties.	Easily implemented. Restrictions on future land use.	Low capital, low maintenance.
		Asphalt	Effective but susceptible to weathering and cracking.	Easily implemented. Restrictions on future land use.	Low capital, high maintenance.
		Concrete	Effective but susceptible to weathering and cracking.	Easily implemented. Restrictions on future land use.	Moderate capital, high maintenance.
		Multi-media-cap	Effective, least susceptible to cracking.	Easily implemented. Restrictions on future land use.	Moderate capital, mod. maintenance.
Collection/ Treatment/ Discharge	Subsurface drains	Interceptor trenches	Effective for downgradient fracture flow interception.	Very difficult to implement--re - quires deep trenching through rock.	Very high capital, low O&M.
	Physical/chemical treatment	Precipitation	Effective and reliable; conventional technology. Requires sludge disposal.	Readily implementable.	High capital, moderate O&M.
		Ion exchange	Effective and reliable; proper pretreatment required.	Readily implementable.	High capital, high O&M.
	Offsite treatment	POTW	Effectiveness and reliability require pilot test to determine.	Readily implementable, permit required.	Moderate capital, low O&M.
		RCRA facility	Effective and reliable treatment; transpor- tation required.	Nearest RCRA facility 250 miles away.	High transporta- tion cost.
	Onsite discharge	Local stream	Effective and reliable.	Readily implementable, Permit required.	Low capital, very low O&M.
	Offsite discharge	POTW	Effective and reliable.	Permit required.	High capital, low O&M.
		Pipeline to river	Effective and reliable.	Permit required.	High capital, low O&M.

Figure 4-5. Evaluation of Process Options - Example.

later phases of the FS when alternatives are refined and evaluated on a sitewide basis.

If modeling of transport processes is undertaken during the alternative development and screening phases of the FS to evaluate removal or collection technologies, and if many contaminants are present at the site, it may be necessary to identify indicator chemicals, as is often done for the baseline risk assessments, to simplify the analysis. Typically, indicator chemicals are selected on the basis of their usefulness in evaluating potential effects on human health and the environment. Commonly selected indicator chemicals include those that are highly mobile and highly toxic.

4.2.5.2 Implementability Evaluation

Implementability encompasses both the technical and administrative feasibility of implementing a technology process. As discussed in Section 4.2.4, technical implementability is used as an initial screen of technology types and process options to eliminate those that are clearly ineffective or unworkable at a site. Therefore, this subsequent, more detailed evaluation of process options places greater emphasis on the institutional aspects of implementability, such as the ability to obtain necessary permits for offsite actions, the availability of treatment, storage, and disposal services (including capacity), and the availability of necessary equipment and skilled workers to implement the technology.

4.2.5.3 Cost Evaluation

Cost plays a limited role in the screening of process options. Relative capital and O&M costs are used rather than detailed estimates. At this stage in the process, the cost analysis is made on the basis of engineering judgment, and each process is evaluated as to whether costs are high, low, or medium relative to other process options in the same technology type. As discussed in Section 4.3, the greatest cost consequences in site remediation are usually associated with the degree to which different general technology types (i.e., containment, treatment, excavation, etc.) are used. Using different process options within a technology type usually has a less significant effect on cost than does the use of different technology types.

4.2.6 Assemble Alternatives

In assembling alternatives, general response actions and the process options chosen to represent the various technology types for each medium or operable unit are combined to form alternatives for the site as a whole. As discussed in Section 4.1.2.1, appropriate treatment and containment options should be developed. To assemble alternatives, general response actions should be combined using different technology types and different volumes of media and/or areas of the site. Often more than one general response action is applied to each medium. For example, alternatives for remediating soil contamination will depend on the type and distribution of contaminants and may include incineration of soil from some portions of the site and capping of others.

For sites at which interactions among media are not significant (i.e., source control actions will not affect ground-water or surface-water responses) the combination of medium-specific actions into site wide alternatives can be made later in the FS process, either after alternatives have been screened or prior to conducting the comparative analysis of alternatives. For example, if media interactions are not of concern, an FS might describe three source control options, three soil remediation options, and four ground-water remediation options, (instead of developing numerous comprehensive sitewide alternatives). Although this approach permits greater flexibility in developing alternatives and simplifies the analyses of sitewide alternatives, it may involve greater effort in developing and analyzing medium-specific options.

Figure 4-6 illustrates how general response actions may be combined to form a range of sitewide alternatives. For this relatively simple example, the two media of interest are soil and ground water. The range of alternatives developed include a no-action alternative (alternative 1); a limited action alternative (alternative 2); source containment options with and without ground water treatment (alternatives 3 and 4); and three alternatives that employ various levels of source treatment, with ground-water collection and treatment (alternatives 5, 6, and 7).

Although not shown in this example, a description of each alternative should be included in the FS report. For the alternatives presented in Figure 4-6, such descriptions would include the locations of areas to be excavated or contained, the approximate volumes of soil and/or ground water to be excavated and collected, the approximate locations of interceptor trenches, the locations of potential city water supply hook-ups, the locations of connections to the local publicly owned treatment works (POTW), management options for treatment residuals, and any other information needed to adequately describe the alternative and document the logic behind the assembly of general response actions into specific remedial action alternatives. In describing alternatives, it may be useful to note those process options that were not screened out and that are represented by those described in the alternative.

General Response Action			1 No Action	2 Limited Action	3 Source Containment; No GW Controls	4 Source Containment; GW Collection, Pretreatment, POTW	5 In Situ Stabilization, Cap; GW Collection, Pretreatment, POTW	6 Biodegradation, Cap; GW Collection, Pretreatment, POTW	7 Incineration; GW Collection, Pretreatment, POTW
Medium	Technology Type	Area or Volume							
Soil	Access Restrictions (Fencing)	Entire Site		●					
	Excavation	All Soil Above 10^{-6}							●
		All Soil Above 10^{-4}			●	●			
	Disposal	Onsite RCRA Landfill			●				
		Offsite RCRA Landfill				●			●
	Treatment Onsite	In Situ Stabilization					●		
		Bioremediation To 10^{-4}						●	
	Incineration Offsite								●
	Capping	All (Remaining) Soil Above 10^{-6}			●	●	●	●	
Ground Water[a]	Alternate Water Supply	All Residents In Affected Area		●	●	●	●		
	Monitoring	All Monitoring Wells Twice A Year	●	●	●	●	●	●	●
	Collection With Interceptor Trenches	All Water Above 10^{-4} Within 10 Yrs.				●	●		
		All Water Above 10^{-6} Within 20 yrs						●	●
	Treatment With Precipitation Onsite	Pretreatment				●	●	●	●
	Discharge	Offsite To POTW				●	●	●	●

[a] This is a conceptual example using the example of carcinogenic risk ranges; however, in general, when MCLs are available they will apply.

Figure 4-6. Assembling a range of alternative examples.

4.3 Alternatives Screening Process

4.3.1 *Alternatives Definition*

Before beginning screening, alternatives have been assembled primarily on medium-specific considerations and implementability concerns. Typically, few details of the individual process options have been identified, and the sizing requirements of technologies or remediation timeframes have not been fully characterized (except for timeframes identified to develop ground-water action alternatives). Furthermore, interactions among media, which may influence remediation activities, have usually not been fully determined, nor have sitewide protectiveness requirements been addressed. Therefore, at this point in the process, such aspects of the alternatives may need to be further defined to form the basis for evaluating and comparing the alternatives before their screening.

4.3.1.1 Specific Objectives

Alternatives are initially developed and assembled to meet a set of remedial action objectives for each medium of interest. During screening, the assembled alternatives should be evaluated to ensure that they protect human health and the environment from each potential pathway of concern at the site or those areas of the site being addressed as part of an operable unit. If more than one pathway is present, such as inhalation of airborne contaminants and ingestion of contaminants in ground water, the overall risk level to receptors should be evaluated. If it is found that an alternative is not fully protective, a reduction in exposure levels for one or more media will need to be made to attain an acceptable risk level.

In refining alternatives, it is important to note that protectiveness is achieved by reducing exposures to acceptable levels, but achieving these reductions in exposures may not always be possible by actually cleaning up a specific medium to these same levels. For example, protection of human health at a site may require that concentrations of contaminants in drinking water be reduced to levels that could not reasonably be achieved for the water supply aquifer; thus, protection could be provided by preventing exposures with the use of a wellhead treatment system. The critical selection of how risk reductions are to be achieved is part of the risk management decisionmaking process.

4.3.1.2 Define Media and Process Options

Alternatives should be defined to provide sufficient quantitative information to allow differentiation among alternatives with respect to effectiveness, implementability, and cost. Parameters that often require additional refinement include the extent or volume of contaminated material and the size of major technology and process options.

Refinement of volumes or areas of contaminated media is important at some sites at which ongoing releases from the source (or contaminated soils) significantly affect contaminant levels in other media (e.g., ground water) because such interactions may not have been addressed when alternatives were initially developed by grouping medium-specific response actions. If interactions among media appear to be important at a site, the effect of source control actions on the remediation levels or time frames for other media should be evaluated.

Figure 4-7 provides an example of such an analysis in which volatile organics in soil are migrating into an underlying aquifer composed of unconsolidated materials. Using a model of transport processes at the site, the effect of different soil removal actions on ground-water remediation (using a specified extraction scheme) could be estimated. In this example, development of alternatives that consider ground water actions independent of soil removal (i.e., the no-soil-removal scenario) could result in underestimating the achievable remediation level or overestimating the time frame for ground-water remediation. This could result in an overestimation of the extraction and treatment requirements for technology processes for ground water. By evaluating soil and ground water actions together, the rates and volumes of ground water extraction to achieve the target remediation levels can be refined more accurately.

After the alternatives have been refined with respect to volumes of media, the technology process options need to be defined more fully with respect to their effectiveness, implementability, and cost such that differences among alternatives can be identified. The following information should be developed, as appropriate, for the various technology processes used in an alternative:

- Size and configuration of onsite extraction and treatment systems or containment structures – For media contaminated with several hazardous substances, it may be necessary to first determine which contaminant(s) impose the greatest treatment requirements; then size or configure accordingly. Similarly, for ground-water extraction technologies at sites with multiple ground-water contaminants, it may be necessary to evaluate which compounds impose the greatest limits on extraction technologies, either because of their chemical/physical characteristics, concentration, or distribution in ground water.

- Time frame in which treatment, containment, or removal goals can be achieved – The remediation time frame is often interdependent on the size of a treatment system or configuration of a ground-water extraction system. The time frame may be determined on the basis of specific remediation goals (e.g., attaining ground-water remediation goals in 10 years), in which case the technology is sized and configured to achieve this; the time frame may also be influenced by technological limitations (such as maximum size consideration, performance capabilities, and/or availability of adequate treatment systems or disposal capacity).

- Rates or flows of treatment – These will also influence the sizing of technologies and time frame within which remediation can be achieved.

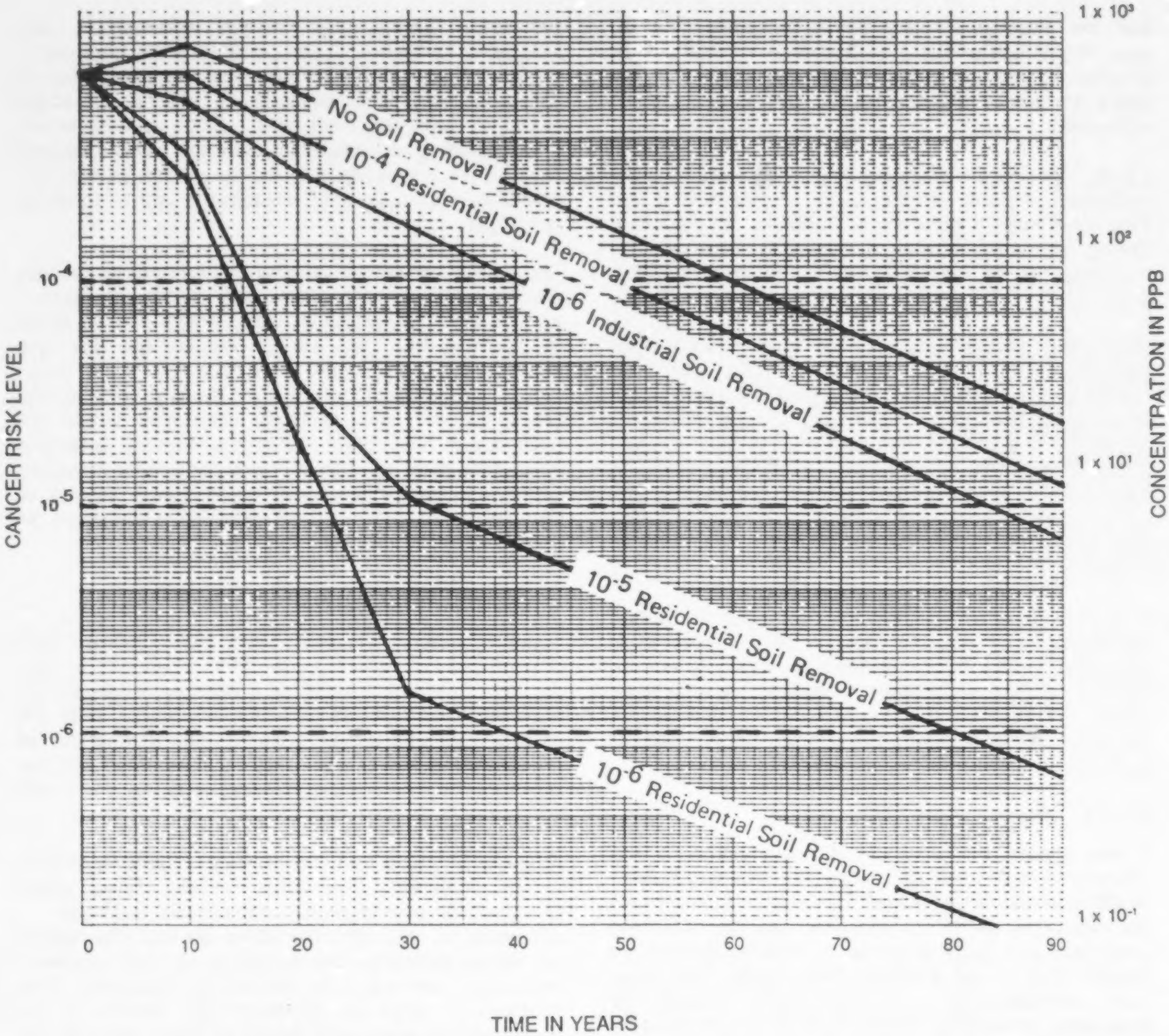


Figure 4-7. **Time to achieve 10^{-4} to 10^{-6} risk level for a single-contaminant for ground water cleanup under various soil removal alternatives.**

- Spatial requirements for constructing treatment or containment technologies or for staging construction materials or excavated soil or waste

- Distances for disposal technologies - These include approximate transport distances to acceptable offsite treatment and disposal facilities and distances for water pipelines for discharge to a receiving stream or a POTW.

- Required permits for offsite actions and imposed limitations - These include National Pollutant Discharge Elimination System (NPDES), pretreatment, and emission control requirements; coordination with local agencies and the public; and other legal considerations. These may also encompass some action-, location-, and chemical-specific ARARs.

4.3.2 Screening Evaluation

Defined alternatives are evaluated against the short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost. Because the purpose of the screening evaluation is to reduce the number of alternatives that will undergo a more thorough and extensive analysis, alternatives will be evaluated more generally in this phase than during the detailed analysis. However, evaluations at this time should be sufficiently detailed to distinguish among alternatives. In addition, one should ensure that the alternatives are being compared on an equivalent basis (i.e., definitions of treatment alternatives are approximately at the same level of detail to allow preparation of comparable cost estimates).

Initially, specific technologies or process options were evaluated primarily on the basis of whether or not they could meet a particular remedial action objective. During alternative screening, the entire alternative is evaluated as to its effectiveness, implementability, and cost.

During the detailed analysis, the alternatives will be evaluated against nine specific criteria and their individual factors rather than the general criteria used in screening. Therefore, individuals conducting the FS should be familiar with the nine criteria (see Section 6.2.2) at the time of screening to better understand the direction that the analysis will be taking. The relationship between the screening criteria and the nine evaluation criteria is conceptually illustrated in Figure 4-8.

It is also important to note that comparisons during screening are usually made between similar alternatives (the most promising of which is carried forward for further analysis); whereas, comparisons during the detailed analysis will differentiate across the entire range of alternatives. The criteria used for screening are described in the following sections.

4.3.2.1 Effectiveness Evaluation

A key aspect of the screening evaluation is the effectiveness of each alternative in protecting human health and the environment. Each alternative should be evaluated as to its effectiveness in providing protection and the reductions in toxicity, mobility, or volume that it will achieve. Both short- and long-term components of effectiveness should be evaluated; short-term referring to the construction and implementation period, and long-term referring to the period after the remedial action is complete. Reduction of toxicity, mobility, or volume refers to changes in one or more characteristics of the hazardous substances or contaminated media by the use of treatment that decreases the inherent threats or risks associated with the hazardous material.

4.3.2.2 Implementability Evaluation

Implementability, as a measure of both the technical and administrative feasibility of constructing, operating, and maintaining a remedial action alternative, is used during screening to evaluate the combinations of process options with respect to conditions at a specific site. Technical feasibility refers to the ability to construct, reliably operate, and meet technology-specific regulations for process options until a remedial action is complete; it also includes operation, maintenance, replacement, and monitoring of technical components of an alternative, if required, into the future after the remedial action is complete. Administrative feasibility refers to the ability to obtain approvals from other offices and agencies, the availability of treatment, storage, and disposal services and capacity, and the requirements for, and availability of, specific equipment and technical specialists.

The determination that an alternative is not technically feasible and is not available will usually preclude it from further consideration unless steps can be taken to change the conditions responsible for the determination. Typically, this type of "fatal flaw" would have been identified during technology screening, and the infeasible alternative would not have been assembled. Negative factors affecting administrative feasibility will normally involve coordination steps to lessen the negative aspects of the alternative but will not necessarily eliminate an alternative from consideration.

4.3.2.3 Cost Evaluation

Typically, alternatives will have been defined well enough before screening that some estimates of cost are available for comparisons among alternatives. However, because uncertainties associated with the definition of alternatives often remain, it may not be practicable to define the costs of alternatives with the accuracy desired for the detailed analysis (i.e., +50 percent to -30 percent).

Absolute accuracy of cost estimates during screening is not essential. The focus should be to make comparative estimates for alternatives with relative accuracy so that cost decisions among alternatives will be sustained as the accuracy of cost estimates improves beyond the screening process. The procedures used to develop cost estimates for alternative screening are similar to those used for the detailed analysis; the only differences would be in the degree of alternative refinement and in the degree to which cost components are developed.

Cost estimates for screening alternatives typically will be based on a variety of cost-estimating data. Bases for screening cost estimates may include cost curves, generic unit costs, vendor information, conventional cost-estimating guides, and prior similar estimates as modified by site-specific information.

Prior estimates, site-cost experience, and good engineering judgments are needed to identify those unique items in each alternative that will control these comparative estimates. Cost estimates for items common to all alternatives or indirect costs (engineering, financial, supervision, outside contractor support, contingencies) do not normally warrant

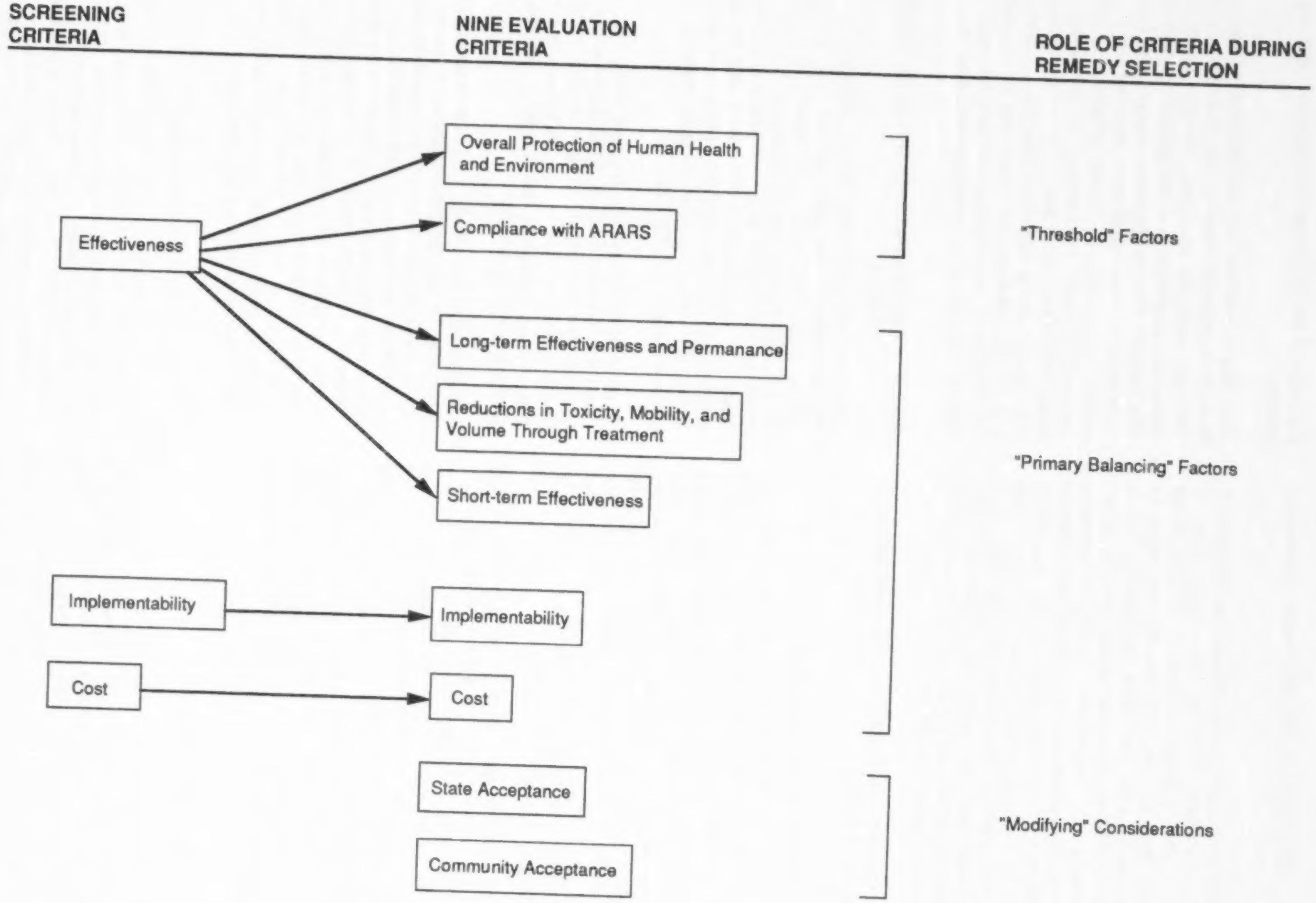

SCREENING CRITERIA
NINE EVALUATION CRITERIA
ROLE OF CRITERIA DURING REMEDY SELECTION
Effectiveness
Overall Protection of Human Health and Environment
Compliance with ARARS
"Threshold" Factors
Long-term Effectiveness and Permanance
Reductions in Toxicity, Mobility, and Volume Through Treatment
Short-term Effectiveness
"Primary Balancing" Factors
Implementability
Implementability
Cost
Cost
State Acceptance
Community Acceptance
"Modifying" Considerations

Figure 4-8. Relationship of Screening Criteria to the Nine Evaluation Criteria.

substantial effort during the alternative screening phase.

Both capital and O&M costs should be considered, where appropriate, during the screening of alternatives. The evaluation should include those O&M costs that will be incurred for as long as necessary, even after the initial remedial action is complete. In addition, potential future remedial action costs should be considered during alternative screening to the extent they can be defined. Present worth analyses should be used during alternative screening to evaluate expenditures that occur over different time periods. By discounting all costs to a common base year, the costs for different remedial action alternatives can be compared on the basis of a single figure for each alternative.

A more detailed discussion of cost evaluations is presented in Chapter 6.

4.3.2.4 Innovative Technologies

Technologies are classified as innovative if they are developed fully but lack sufficient cost or performance data for routine use at Superfund sites. In many cases, it will not be possible to evaluate alternatives incorporating innovative technologies on the same basis as available technologies, because insufficient data exist on innovative technologies. If treatability testing is being considered to better evaluate an innovative technology, the decision to conduct a test should be made as early in the process as possible to avoid delays in the RI/FS schedule.

Innovative technologies would normally be carried through the screening phase if there were reason to believe that the innovative technology would offer significant advantages. These advantages may be in the form of better treatment performance or implementability, fewer adverse impacts than other available approaches, or lower costs for similar levels of performance. A "reasonable belief" exists if indications from other full-scale applications under similar circumstances or from bench-scale or pilot-scale treatability testing supports the expected advantages.

4.3.3 Alternative Screening

4.3.3.1 Guidelines for Screening

Alternatives with the most favorable composite evaluation of all factors should be retained for further consideration during the detailed analysis. Alternatives selected for further evaluation should, where practicable, preserve the range of treatment and containment technologies initially developed. It is not a requirement that the entire range of alternatives originally developed be preserved if all alternatives in a portion of the range do not represent distinct viable options.

The target number of alternatives to be carried through screening should be set by the project manager and the lead agency on a site-specific basis. It is expected that the typical target number of alternatives carried through screening (including containment and no-action alternatives) usually should not exceed 10. Fewer alternatives should be carried through screening, if possible, while adequately preserving the range of remedies. If the alternatives being screened are still medium-specific and do not address the entire site or operable unit, the number of alternatives retained for each specific medium should be considerably less than 10.

4.3.3.2 Selection of Alternatives for Detailed Analysis

Once the evaluation has been conducted for each of the alternatives, the lead agency and its contractor should meet with the support agency to discuss each of the alternatives being considered. This meeting does not correspond to a formal quality control review stage but provides the lead agency and its contractor with input from the support agency and serves as a forum for updating the support agency with the current direction of the FS.

The alternatives recommended for further consideration should be agreed upon at this meeting so that documentation of the results of alternative screening is complete; any additional investigations that may be necessary are identified; and the detailed analysis can commence.

Unselected alternatives may be reconsidered at a later step in the detailed analysis if similar retained alternatives continue to be evaluated favorably or if information is developed that identifies an additional advantage not previously apparent. This provides the flexibility to double check a previous decision or to review variations of alternatives being considered (e.g., consideration of other similar process options). However, it is expected that under most circumstances, once an alternative is screened out it will not be reconsidered for selection.

4.3.3.3 Post-screening Tasks

The completion of the screening process leads directly into the detailed analysis and may serve to identify additional investigations that may be needed to adequately evaluate alternatives. To ensure a smooth transition from the screening of alternatives to the detailed analysis, it will be necessary to identify and begin verifying action-specific ARARs and initiate treatability testing (if not done previously) and additional site characterization, as appropriate.

Although the consideration of action-specific ARARs begins earlier as process options are combined, the identification of action-specific ARARs will need to be more definitive as the alternatives become better defined. At the conclusion of screening, sufficient information should exist on the technologies and the most probable configurations of technologies so that the lead agency and support agency can better define and agree on action-specific ARARs. As with chemical-specific ARARs, action-specific ARARs should include all Federal requirements and any State requirements that either are more stringent than Federal ARARs or specify requirements where no Federal ARARs exist.

Once the field of alternatives has been narrowed, the technology processes of greatest interest can be identified. At this point, the need for treatability tests (if not identified earlier) can be determined for process options that will require additional data for detailed analysis. Although the results of treatability testing may not be used until the detailed analysis, they should be initiated as early in the process as possible to minimize any potential delays on the FS schedule. The type and scope of treatability tests depends on the expected data requirements for detailed analysis of alternatives. Factors involved in determining the need for and scope of treatability studies are discussed in Chapter 5.

In some cases, the need for additional site characterization may also be identified during the screening phase. Because the nature and extent of contamination is usually well defined at this time, additional field investigations should be conducted only to better define the effect of site conditions on the performance of the technology processes of greatest interest.

4.4 Community Relations During Alternative Development and Screening

The community relations activities implemented for site characterization may also be appropriate during the development of alternatives. Activities focus on providing information to the community concerning the development and screening of remedial alternatives and obtaining feedback on community interests and concerns associated with such alternatives. Community relations activities should be site- and community-specific and are usually stipulated in the community relations plan that is prepared during scoping activities. Community relations activities during the development of alternatives may include, but are not limited to, a fact sheet describing alternatives identified as potentially feasible, a workshop presenting citizens with the Agency's considerations for developing alternatives, briefings for local officials and concerned citizens on alternatives under consideration, a small group meeting for citizens involved with the site, and news releases describing technologies being evaluated. It is important to note that public interest typically increases as the feasibility study progresses; and that the technical adequacy of a remedy does not ensure community acceptance. Therefore, the community relations activities should be planned and conducted to address such interest and potential concerns.

If alternatives are being developed concurrently with the RI site characterization, information on the screening of technologies and remedial alternative development should be included in public information materials and activities prepared during site characterization. If alternatives are developed after site characterization, additional community relations activities should be conducted. In general, community relations activities during alternative development and screening are most appropriate if citizens are significantly concerned over site conditions and RI/FS activities that are being implemented at the site. The level of effort for community relations at this phase should be described in the community relations plan.

4.5 Reporting and Communication During Alternative Development and Screening

Although no formal report preparation is required during the development and screening of alternatives (except whatever routine administrative and project management tracking methods have been designated for use by the lead agency and its contractor(s))[7], some form of written documentation of the methods, rationale, and results of alternative screening (e.g., graphical representation similar to Figures 4-5 and 4-6 or a technical memorandum) needs to be provided to the lead and support agencies. If a technical memorandum is prepared, it can serve as the basis for later development of the chapter(s) in the FS report that discusses the development and screening of alternatives.

Communication among the lead and support agencies and their contractor(s) is very important to obtain input and agreement on the technologies or processes and alternatives considered for implementation at the site. As shown in Table 4-2, communication should occur to facilitate the initial screening of technologies and process options, to agree on what additional site data may be needed, and to gain input and agreement on the choice of representative processes and combinations to be used to assemble alternatives. In addition, the following key coordination points are required:

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[7] The RPM may require a written deliverable from the PRPs during alternative development and screening for a PRP-lead RI/FS.

- The lead and support agencies should agree on the set of alternatives selected for detailed analysis.
- The lead and support agencies must coordinate identification of action-specific ARARs.
- The lead agency and its contractor are to evaluate the need for any additional investigations that may be needed before they conduct the detailed analysis.

For purposes of speed and efficiency, the preferred approach for the exchange of information is through meetings. However, other approaches that facilitate effective review and input (e.g., technical memorandums for review) may be used at the lead agency's discretion.

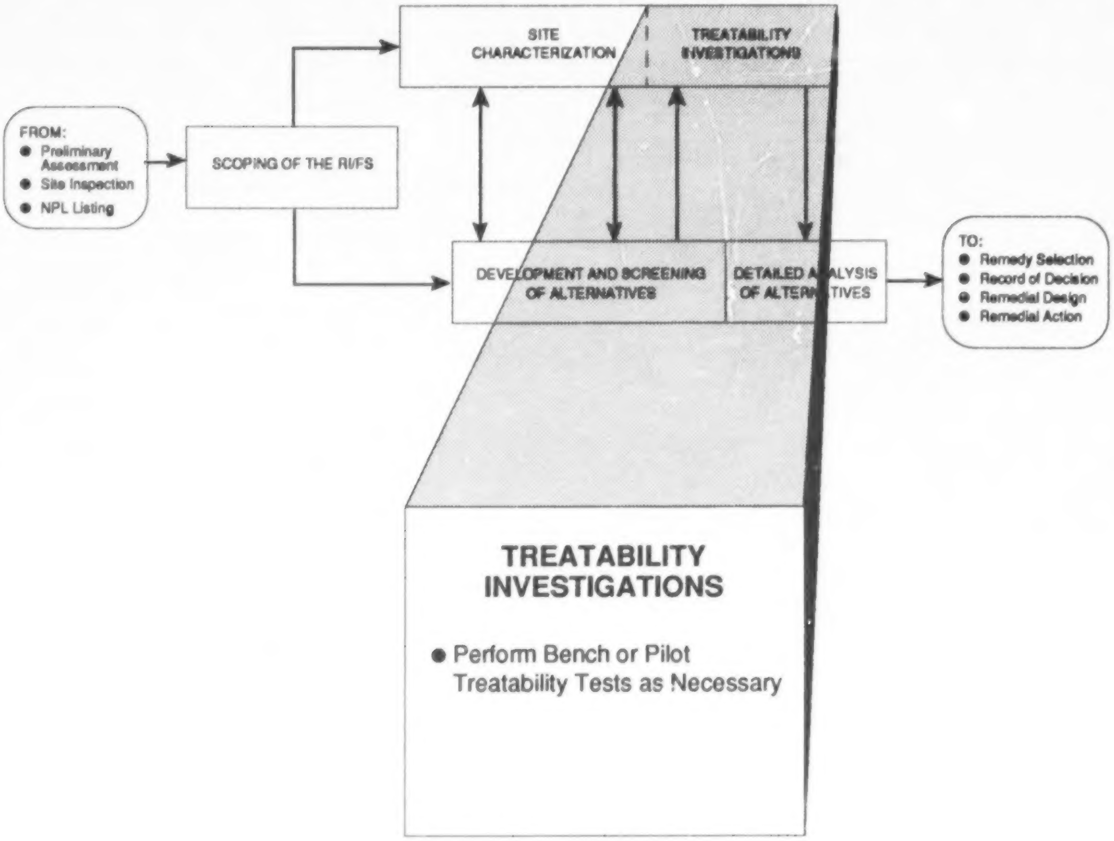
Because the final RI/FS report may eventually be subject to judicial review, the procedures for evaluating, defining, and screening alternatives should be well documented, showing the rationale for each step. The following types of information should be documented in the final RI/FS report to the extent possible:

- Chemical- and/or risk-based remedial objectives associated with the alternative
- Modifications to any media-specific alternatives initially developed to ensure that risk from multiple-pathway exposures and interactions among source- and ground-water-remediation strategies are addressed
- Definition of each alternative including extent of remediation, volume of contaminated material, size of major technologies, process parameters, cleanup timeframes, transportation distances, and special considerations
- Notation of process options that were not initially screened out and are being represented by the processes comprising the alternative

Table 4-2. Reporting and Communication During Alternative Development and Screening

Information Needed	Purpose	Potential Methods for Information Provision
All potential technologies included for consideration	For lead agency and contractor to identify potential technologies; for lead agency to obtain support agency review and comment	Meeting Tech Memo Other
Need for additional field data or treatability studies	For lead agency and contractor to determine whether more field data or treatability tests are needed to evaluate selected technologies; for lead agency to obtain support agency review and comment	Meeting Tech Memo Other
Process evaluation and alternative development	For lead agency and contractor to communicate and reach agreement on technology screening and alternative development; for lead agency to obtain support agency review and comment	Meeting Tech Memo Other
Results of alternative screening (if conducted)	For lead agency and contractor to communicate and reach agreement on alternative screening;for lead agency to obtain support agency review and comment	Meeting Tech Memo Other
Identification of action-specific ARARs	For lead agency to obtain input from the support agency on action-specific ARARs	Meeting Letter Other
Need for additional investigation	For lead agency and contractor to determine whether additional investigations are needed to evaluate selected alternatives; for lead agency to obtain support agency review and comment	Meeting Tech Memo Other

CHAPTER 5
TREATABILITY INVESTIGATIONS


FROM:
Preliminary Assessment
Site Inspection
NPL Listing
SCOPING OF THE RI/FS
SITE CHARACTERIZATION
TREATABILITY INVESTIGATIONS
DEVELOPMENT AND SCREENING OF ALTERNATIVES
DETAILED ANALYSIS OF ALTERNATIVES
TO:
Remedy Selection
Record of Decision
Remedial Design
Remedial Action
TREATABILITY INVESTIGATIONS
Perform Bench or Pilot Treatability Tests as Necessary

Chapter 5
Treatability Investigations

5.1 Introduction

As discussed earlier, the phased RI/FS process is intended to better focus the site investigation so that only those data necessary to support the RI/FS and the decision-making process are collected. Data needs are initially identified on the basis of the understanding of the site at the time the RI/FS is initially scoped. Therefore, initial sampling and testing efforts may be limited until a more complete understanding of the site allows subsequent sampling efforts to be better focused. As site information is collected during the RI and alternatives are being developed, additional data needs necessary to adequately evaluate alternatives during the detailed analysis are often identified. These additional data needs may involve the collection of site characterization data, as described in Chapter 3, or treatability studies to better evaluate technology performance. This chapter is intended to provide an overview of the types of treatability studies (i.e., bench scale, pilot scale) that may be used, their specific purposes, and important factors that need to be considered when contemplating their use.

5.1.1 *Objectives of Treatability Investigations*

Treatability studies are conducted primarily to achieve the following:

- Provide sufficient data to allow treatment alternatives to be fully developed and evaluated during the detailed analysis and to support the remedial design of a selected alternative
- Reduce cost and performance uncertainties for treatment alternatives to acceptable levels so that a remedy can be selected

5.1.2 *Overview of Treatability Investigations*

Treatability studies to collect data on technologies identified during the alternative development process are conducted, as appropriate, to provide additional information for evaluating technologies. The RI/FS contractor and the lead agency's RPM must review the existing site data and available information on technologies to determine if treatability investigations are needed. As discussed earlier, the need for treatability testing should be identified as early in the RI/FS process as possible. A decision to conduct treatability testing may be made during project scoping if information indicates such testing is desirable. However, the decision to conduct these activities must be made by weighing the cost and time required to complete the investigation against the potential value of the information in resolving uncertainties associated with selection of a remedial action. In some situations a specific technology that appears to offer a substantial savings in costs or significantly greater performance capabilities may not be identified until the later phases of the RI/FS. Under such circumstances it may be advantageous to postpone completion of the RI/FS until treatability studies can be completed. Project managers will need to make such decisions on a case by case basis. In other situations, treatability investigations may be postponed until the remedial design phase.

The decision process for treatability investigations is shown conceptually in Figure 5-1 and consists of the following steps:

- Determining data needs
- Reviewing existing data on the site and available literature on technologies to determine if existing data are sufficient to evaluate alternatives
- Perform treatability tests, as appropriate, to determine performance, operating parameters, and relative costs of potential remedial technologies
- Evaluating the data to ensure that DQOs are met

5.2 Determination of Data Requirements

To the extent possible, data required to assess the feasibility of technologies should be gathered during the site characterization (e.g., moisture and heat content data should be collected if incineration of an organic waste is being considered). Because data requirements will depend on the specific treatment process and the contaminants and matrices being considered, the results of the site characterization will influence the types of alternatives developed and screened, which will in turn influence additional data

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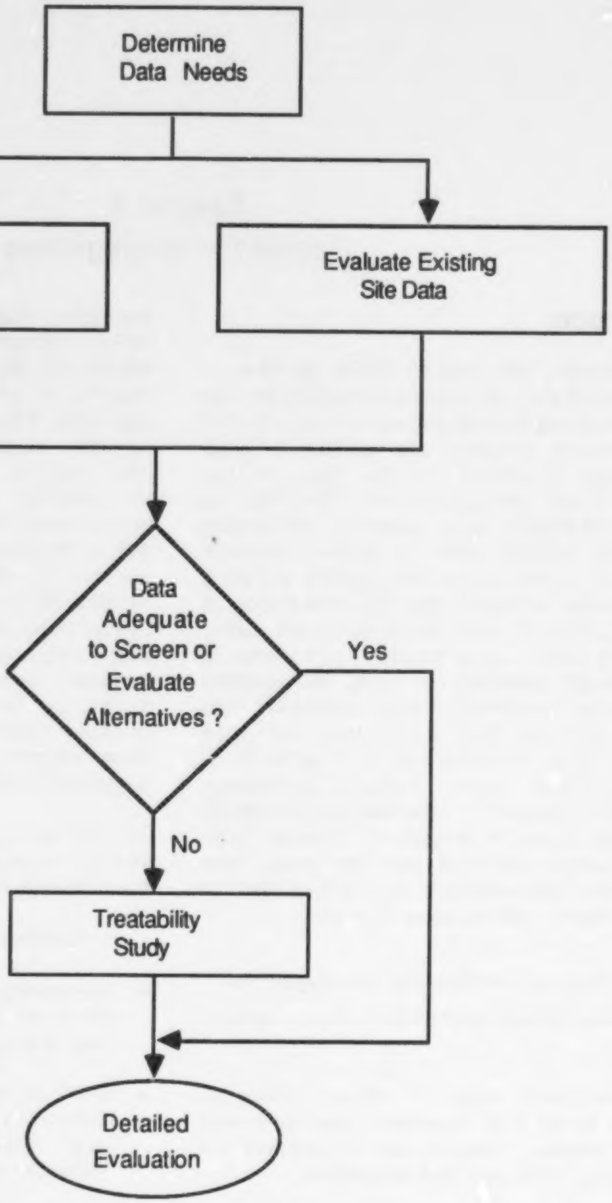
Determine Data Needs
Evaluate Existing Technology Data
Evaluate Existing Site Data
Data Adequate to Screen or Evaluate Alternatives ?
Yes
No
Treatability Study
Detailed Evaluation

Figure 5-1. Treatability investigations.

needs. However, data collected during site characterization will not always be adequate for assessing the feasibility of remedial technologies, and, in fact, the need for detailed data from treatability tests may not become apparent until the initial screening of alternatives has been completed. A description of data requirements for selected technologies is presented in Table 5-1. The *Technology Screening Guide for Treatment of CERCLA Soils and Sludges* (U.S. EPA, September 1988) summarizes data needs for a larger number of available and innovative technologies. The Superfund Innovative Technology Evaluation (SITE) program is another source to assist with the identification of data needs and to obtain performance information on innovative technologies.

Additional data needs can be identified by conducting a more exhaustive literature survey than was originally conducted when potential technologies were initially

Table 5-1. Typical Data Requirements for Remediation Technologies

Technology	Waste Matrix	Example Data Required
Thermal Destruction	Soils	Moisture content Heat value Chlorine content Destruction efficiency
	Liquids	Heat value Concentration of metals Destruction efficiency
Air Stripping	Ground Water	Concentration of volatile contaminants. Concentration of non-volatile contaminants Contaminant removal efficiencies (obtainable from mathematical models)
Metal Hydroxide Precipitation	Ground Water	Metals concentration Contaminant removal efficiency Sludge generation rate and composition
In Situ Vapor Extraction	Soils	Soil type Particle size distribution. Concentration of volatile compounds Presence of non-volatile contaminants Contaminant removal efficiencies (usually requires bench- or pilot-scale work)

Note: Tables used in this outline are only partial examples.

being identified. The objectives of a literature survey are as follows:

- Determine whether the performance of those technologies under consideration have been sufficiently documented on similar wastes considering the scale (e.g., bench, pilot, or full) and the number of times the technologies have been used
- Gather information on relative costs, applicability, removal efficiencies, O&M requirements, and implementability of the candidate technologies
- Determine testing requirements for bench or pilot studies, if required

5.3 Treatability Testing

Certain technologies have been demonstrated sufficiently so that site-specific information collected during the site characterization is adequate to evaluate and cost those technologies without conducting treatability testing. For example, a ground-water investigation usually provides sufficient information from which to size a packed tower air stripper and prepare a comparative cost estimate. Other examples of when treatability testing may *not* be necessary include:

- A developed technology is well proven on similar applications.
- Substantial experience exists with a technology employing treatment of well-documented waste materials. (For example, air stripping or carbon adsorption of ground water containing organic compounds for which treatment has previously proven effective.)
- Relatively low removal efficiencies are required (e.g., 50 to 90 percent), and data are already available.

Frequently, technologies have not been sufficiently demonstrated or characterization of the waste alone is insufficient to predict treatment performance or to estimate the size and cost of appropriate treatment units. Furthermore, some treatment processes are not sufficiently understood for performance to be predicted, even with a complete characterization of the wastes. For example, often it is difficult to predict biological toxicity in a biological treatment plant without pilot tests. When treatment performance is difficult to predict, an actual testing of the process may be the only means of obtaining the necessary data. In fact, in some situations it may be more cost-effective to test a process on the actual waste than it would be to characterize the waste in sufficient detail to predict performance.

Treatability testing performed during an RI/FS is used to adequately evaluate a specific technology, including evaluating performance, determining process sizing, and estimating costs in sufficient detail to support the remedy-selection process. Treatability testing in the RI/FS is not meant to be used solely to develop detailed design or operating parameters that are more appropriately developed during the remedial design phase.

Treatability testing can be performed by using bench-scale or pilot-scale techniques, which are described in detail in the following sections. However, in general, treatability studies will include the following steps:

- Preparing a work plan (or modifying the existing work plan) for the bench or pilot studies

- Performing field sampling, and/or bench testing, and/or pilot testing
- Evaluating data from field studies, and/or bench testing, and/or pilot testing
- Preparing a brief report documenting the results of the testing

5.3.1 *Bench-Scale Treatability Studies*

Bench testing usually is performed in a laboratory, in which comparatively small volumes of waste are tested for the individual parameters of a treatment technology. These tests are generally used to determine if the "chemistry" of the process works and are usually performed in batch (e.g., "jar tests"), with treatment parameters varied one at a time. Because small volumes and inexpensive reactors (e.g., bottles or beakers) are used, bench tests can be used economically to test a relatively large number of both performance and waste-composition variables. It is also possible to evaluate a treatment system made up of several technologies and to generate limited amounts of residuals for evaluation. Bench tests are typically performed for projects involving treatment or destruction technologies. However, care must be taken in attempting to predict the performance of full-scale processes on the basis of these tests.

Bench-scale testing is useful for a developing technology, because it can be used to test for a wide variety of operating conditions.[1] In such cases, bench tests can also be used to determine broad operating conditions to allow optimization during additional bench or possibly larger-scale pilot tests to follow.

Bench-scale testing usually consists of a series of tests, with the results of the previous analysis determining the next set of conditions to evaluate. The first tests usually cover a broad range of potential operating conditions in order to narrow the conditions for subsequent tests. For example, pH is the most important parameter for hydroxide precipitation of heavy metals. An initial "screening" jar test might be performed in which the pH range is varied from 7 through 12 in whole pH units. After finding a minimum metals concentration at pH 9, additional testing could be performed at narrower pH intervals around 9. The initial screening tests need not be performed to the same high level of accuracy used in the final tests to predict treatment effectiveness.

Bench-scale testing can usually be performed over a few weeks or months, and the costs are usually only a small portion of the total RI/FS cost.

Bench-scale testing should be performed, as appropriate, to determine the following:

- Effectiveness of the treatment alternative on the waste (note that for some technologies bench-scale testing may not be sufficient to make a final effectiveness determination)
- Differences in performance between competing manufacturers (e.g., activated carbon adsorption isotherms, polymer jar tests)
- Differences in performance between alternative chemicals (e.g., alum versus lime versus ferric chloride versus sodium sulfide)
- Sizing requirements for pilot-scale studies (e.g., chemical feed systems)
- Screening of technologies to be pilot tested (e.g., sludge dewatering)
- Sizing of those treatment units that would sufficiently affect the cost of implementing the technology
- Compatibility of materials with the waste

The preplanning information needed to prepare for bench-scale treatability testing includes: a waste sampling plan; waste characterization; treatment goals (e.g., how clean or resistant to leaching does the waste need to be); data requirements for estimating the cost of the technology being evaluated (e.g., sufficient for an order of magnitude cost estimate (i.e., +50/-30 percent)); and information needed for procurement of equipment and analytical services.

5.3.2 *Pilot-Scale Treatability Studies*

Pilot studies are intended to simulate the physical as well as chemical parameters of a full-scale process; therefore, the treatment unit sizes and the volume of waste to be processed in pilot systems greatly increase over those of bench scale. As such, pilot tests are intended to bridge the gap between bench-level analyses and full-scale operation, and are intended to more accurately simulate the performance of the full-scale process.

Pilot units are designed as small as possible to minimize costs, yet large enough to get the data required for scaling up. Pilot units are usually sized to minimize the physical and geometric effects of test equipment on treatment performance to simulate full-scale performance. Examples of these effects include mixing, wall effects, accurate settling data, and generation of sufficient residues (sludges, off gases, etc.) for additional testing (dewatering, fixation, etc.). Pilot units are operated in a manner as similar as possible to the operation of the full-scale system (i.e., if the full-scale system will be operated continuously, then the pilot system would usually be operated continuously).

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[1] Bench tests may also be conducted for well-developed and documented technologies that are being applied to a new waste.

In many instances, significant time is required to make a changeover in operating conditions of a pilot plant and get a reliable result of the change. Therefore, time and budget constraints often limit the ability to test a large number of operating conditions. Since pilot tests usually require large volumes of waste that may vary in characteristics, consideration should be given to performing tests on wastes that are representative of actual site conditions and full-scale operations (e.g., it may be necessary to blend or spike wastes to test all waste characteristics anticipated at the site and/or to conduct onsite tests using mobile laboratories).

In addition to the preplanning requirements for bench-scale tests, information needed to prepare for a pilot-scale treatability test includes:

- Site information that would affect pilot-test requirements (i.e., waste characteristics, power availability, etc.)
- Waste requirements for testing (i.e., volumes, pretreatment, etc.)
- Data requirements for technologies to be tested

Because substantial quantities of material may be processed in a pilot test and because of the material's hazardous characteristics, special precautions may be required in handling transport and disposal of processed waste. It may be necessary to obtain an agreement with a local sewer authority or cognizant State agencies or to obtain an NPDES permit for offsite discharge of treated effluent. Solid residuals must be disposed of properly offsite or stored onsite to be addressed as part of the remedial action.

5.4 Bench Versus Pilot Testing

Alternatives involving treatment or destruction technologies may require some form of treatability testing, if their use represents first-of-its-kind applications on unique or heterogeneous wastes.

Once a decision is made to perform treatability studies, the RI/FS contractor and lead agency remedial project manager will have to decide on the type of treatability testing to use. This decision must always be made taking into account the technologies under consideration, performance goals, and site characteristics.

The choice of bench versus pilot testing is affected by the level of development of the technology. For a technology that is well developed and tested, bench studies are often sufficient to evaluate performance on new wastes. For innovative technologies, however, pilot tests may be required since information necessary to conduct full-scale tests is either limited or nonexistent.

Pilot studies are usually not required for well-developed technologies except when treating a new waste type or matrix that could affect the physical operating characteristics of a treatment unit. For example, incineration of fine sands or clay soils in a rotary kiln that has been developed for coarser solids can result in carryover of fine sands into the secondary combustion chamber.

During the RI/FS process, pilot- scale studies should be limited to situations in which bench-scale testing or field sampling of physical or chemical parameters provide insufficient information from which to evaluate an alternative (e.g., it is difficult to evaluate the ability of a rotary kiln incinerator to handle a new waste matrix using a bench-scale test). Pilot-scale tests may also be required when there is a need to investigate secondary effects of the process, such as air emissions, or when treatment residues (sludge, air emissions) are required to test secondary treatment processes.

Because of the time required to design, fabricate, and install pilot- scale equipment and to perform tests for a reasonable number of operating conditions, conducting a pilot study can add significant time and cost to the RI/FS. The decision to perform a pilot test should, therefore, be considered carefully and made as early in the process as possible to minimize potential delays to the FS.

To determine the need for pilot testing, the potential for improved performance or savings in time or money during the implementation of a technology should be balanced against the additional time and cost for pilot testing during the RI/FS. Technologies requiring pilot testing should also be compared to technologies that can be implemented without pilot testing. Innovative technologies should be considered if they offer the potential for more efficient treatment, destruction of the waste, or significant savings in time or money required to complete a remedial action.

The final decision as to how much treatability testing (or collection of additional data of any kind) should be undertaken involves balancing the value of the additional data against increased cost, schedule delay, and level of allowable uncertainty in the remedy-selection process. Generally, one of the following choices must be made:

- Collect more data using treatability testing
- Provide additional safety factors in the remedial design to accommodate the uncertainties
- Proceed with the remedy selection, accepting the uncertainty and the potential cost and performance consequences

The final decision may be a combination of several of these choices. The lead agency's RPM must base the decision upon the characteristics of the site, the cost of the studies, and the uncertainties of proceeding without them.

Table 5-2 provides a comparison between bench and pilot studies, and Table 5-3 shows examples of bench and pilot testing programs.

5.4.1 Testing Considerations

Shipment of substantial volumes of contaminated material from a site for testing can prove to be difficult;[2] residual material not consumed in testing will need to be disposed of safely, and the disposal must be adequately documented. Therefore, the volume of materials to be tested offsite should be minimized to avoid related problems.

A second testing consideration is the possible difficulty of getting a representative sample of waste for treatability testing. For example, although ground-water samples collected from monitoring wells during site characterization may be available for testing treatment technologies, separate extraction wells may need to be used to produce the required ground- water flow patterns during remedial actions. Consequently, because the characteristics of ground water from extraction wells may be different from monitoring wells, representative waste samples may be unavailable until extraction wells are installed and pumped.

A similar concern arises when trying to obtain representative samples for testing the treatment of contaminated soil. Since the soil characteristics will vary both horizontally and vertically on the site it may not be possible to obtain a sample that fully represents full-scale conditions without blending or spiking.

5.4.2 Data Quality Objectives

The data quality required for analytical results of treatability tests is a key concern since it greatly affects the cost and time required for the analyses. Analytical levels and corresponding levels of quality are discussed in Chapter 2 of this guidance.

Since the results of bench and pilot studies are used to support selection of a remedial alternative, results of such studies will support the ROD and become part of the Administrative Record. Furthermore, results of treatability testing also may be used on other sites with similar characteristics. Therefore, procedures followed in testing should be well documented. Sampling and analyses for tests used to develop predictive results will need to be performed with the same level of accuracy and care that was used during the site characterization. Because cost and time required for analyses increase significantly with increased quality, potential savings can be derived by carefully determining the level(s) of data quality necessary for each analytical level required.

Table 5-4 presents the data quality usually required for the various analyses that may be performed during treatability investigations. Bench- and pilot-scale testing require some moderate and some high-quality data. Sufficient high-quality data are needed to document treatment performance of the technologies considered for further evaluation.

5.5 Treatability Test Work Plan

Laboratory testing can be expensive and time consuming. A well-written work plan is a necessary document if a treatability testing program is to be completed on time, within budget, and with accurate results. Preparation of a work plan provides an opportunity to run the test mentally and review comments before starting the test. It also reduces the ambiguity of communication between the lead agency's RPM, the contractor's project manager, the technician performing the test, and the laboratory technician performing the analyses on test samples. The treatability test work plan, which may be an amendment to the original work plan, if the need for the treatability tests was not identified until later in the process, or a separate one specifically for this phase. Regardless, the work plan should be reviewed and approved by the lead agency's RPM. The RPM and RI/FS contractor should determine the appropriate level of detail for the work plan since a detailed plan is not always needed and will require time to prepare and approve. In some situations the original work plan may adequately describe the treatability tests and a separate plan is not required (e.g., the need for treatability testing can be identified during the scoping phase if existing information is sufficient). Section

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[2] See 40 CFR parts 260 and 261 for specific details on treatability study sample exemptions.

Table 5-2. Bench and Pilot Study Parameters

Parameter	Bench	Pilot
Purpose	Define process kinetics, material compatibility, impact of environmental factors, types of doses of chemicals, active mechanisms, etc.	Define design and operation criteria, materials of construction, ease of material handling and construction, etc.
Size	Laboratory or bench top	1-100% of full scale
Quantity of Waste and Materials Required	Small to moderate amounts	Relatively large amounts
Number of Variables That Can Be Considered	Many	Few (greater site-specificity)
Time Requirements	Days to weeks	Weeks to months
Typical Cost Range	0.5-2% of capital costs of remedial action	2-5% of capital costs of remedial action[1]
Most Frequent Location	Laboratory	Onsite
Limiting Considerations	Wall, boundary and mixing effects; volume effects; solids processing difficult to simulate; transportation of sufficient waste volume	Limited number of variables; large waste volume required; safety, health, and other risks; disposal of process waste material

[1] Actual percentage cost of pilot testing will depend significantly on the total cost of the remedial action.

2.3.1 and Appendix B.2 provide additional information on work plan preparation.

5.5.1 *Bench-Scale Treatability Work Plan*

Table 5-5 provides a suggested work plan format for bench-scale testing; the various sections of the recommended format for the work plan are described below.

- *Project Description and Site Background* – Briefly describe the site and the types, concentrations, and distributions of contaminants of concern (concentrating on those for which the technology is being considered).

- *Remedial Technology Description* – Give a brief description of the technology(ies) to be tested.

- *Test Objectives* – Describe the purpose of the test, the data that are to be collected from the bench-scale test, and how the data will be used to evaluate the technology.

- *Specialized Equipment and Materials* – Describe unique equipment or reagents required for the test.

- *Experimental Procedures* – List specific steps to be performed in carrying out the bench-scale test; include volumes to be tested, descriptions of reactors to be employed, and materials needed (i.e., transfer by graduated cylinder 500 ml of waste to a 600 ml borosilicate glass beaker). Specify the accuracy of measurements by specifying standard laboratory glassware (e.g., a graduated cylinder has 5 percent accuracy whereas a pipet has 1 percent) and how samples are to be taken, which containers are to be used, which preservatives, etc.

- *Treatability Test Plan* – Include the variable conditions that are to be tested (e.g., a combination of 4 pH units and 5 doses of a chemical would produce 40 discrete tests [if replicated]); include parameters to be measured if they vary for different test conditions.

- *Analytical Methods* – The analytical method is dependent on test objectives, technology, waste, and other site factors. Survey available analytical methods and select the most appropriate. Describe analytical procedures or cite and reference standard procedures to be employed and define the level of accuracy needed for each of the analyses (perform initial testing to roughly determine optimal operating conditions; and use moderately accurate analytical techniques or analyses of only one or a few indicator compound(s) to greatly reduce the time and cost of these initial tests). After achieving best treatment, perform more complete and accurate testing to confirm the earlier results. Most bench tests require results in short order to allow varied test runs. Bench tests remote from the analyzing laboratory are difficult; therefore, analyze the duplicate final or check samples by the CLP, if necessary.

- *Data Management* – Testing procedures must be well documented, using bound notebooks, photographs, etc.; provisions need to be made for making backup copies of critical items of data. Describe the parameters to be measured, accuracy that the results are to be recorded to, and how these are to be recorded. Prepare a sample data sheet to be used in the bench test;

Table 5-3. Examples of Bench- and Pilot-Scale Testing Programs

Remedial Technology	Example Testing Programs
A. Air Pollution and Gas Migration Control 1. Capping 2. Dust Control 3. Vapor Collection and Treatment (carbon adsorption, air stripping, etc.)	Bench: Soil density and bearing capacity vs. moisture content curves for proposed capping materials Pilot: In-place soil densities; determination of gas withdrawal rates to control releases
B. Surface Water Controls 1. Capping 2. Grading 3. Revegetation 4. Diversion and Collection	Bench: Column testing of capping material compatibility with wastes present Pilot: In-place testing of geotextiles for control of erosion in grassed diversion ditches
C. Leachate and Ground-Water Controls 1. Containment barriers (slurry walls, grout curtains, etc.) 2. Ground-water pumping (well points, suction wells, etc.) 3. Subsurface collection drains 4. Permeable treatment beds (limestone, activated carbon) 5. Capping	Bench: Determination of basicity and headloss vs. grain size of limestone materials for a treatment bed; determination of chemical compatibility of compacted clay with a leachate stream Pilot: In-place testing of a soil-type and grain-size specification and tile-drain configuration for a subsurface collection drain
D. Direct Waste Control 1. Thermal Treatment 2. Solidification/Stabilization 3. Biological Treatment • Activated sludge • Facultative lagoons • Trickling filters 4. Chemical Treatment • Oxidation/reduction • Precipitation • Neutralization • Ion exchange resins 5. Physical Treatment • Carbon adsorption • Flocculation • Sedimentation • Membrane processes • Dissolved air flotation • Air stripping • Wet air oxidation 6. In Situ Treatment • Vapor extraction • Soil flushing • Microbial degradation • Neutralization/detoxification • Precipitation • Nitrification 7. Land Disposal (landfill, land application)	Bench: Characterization of chemical and heat content of hazardous waste mixes; chemical, physical, and biological treatability studies to define rate constants, minimal-maximal loading rates and retention times, optinal pH and temperature, sludge generation rates and characteristics, and oxygen transfer characteristics; chemical type and dose rates; solids flux rate vs. solids concentration in sludge thickening systems; air/volume ratios for stripping towers Pilot: Test burns to determine retention times, combustion-chamber and after-burner temperatures, destruction and removal efficiency, and fuel requirements for the incineration of a waste; endurance performance tests on membranes in reverse-osmosis units for ground-water treatment; in situ microbial-degradation testing of nutrient-dose and aeration rates to support in-place degradation of underground leak; evaluation of in-place mixing procedures for the solidification of a sludge in a lagoon
E. Soil and Sediment Containment and Removal 1. Excavation 2. Dredging 3. Grading 4. Capping 5. Revegetation	Bench: Determination of soil-adsorptive (cation exchange capacity) properties and chemical composition Pilot: Small-scale dredging to assess sediment resuspension or production rates

Table 5-4. Data Quality for Treatability Investigations

Analytical Level	Field Data	Bench/Pilot Data
Level II/ Level III	Feasibility screening	Testing to optimize operating conditions Monitoring Predesign sizing
Level IV/ Level V	Enforcement related evaluations and recommendations of alternatives	Establish design criteria establishing standards documenting performance in treatability studies to screen alternatives

include procedures to be employed to ensure that the results are protected from loss.

- *Data Analysis and Interpretation* – Describe in detail the procedures to be followed to reduce

Table 5-5. Suggested Format for Bench-Scale Work Plan

1. Project Description and Site Background
2. Remediation Technology Description
3. Test Objectives
4. Specialized Equipment and Materials
5. Laboratory Test Procedures
6. Treatability Test Plan Matrix and Parameters to Measure
7. Analytical Methods
8. Data Management
9. Data Analysis and Interpretation
10. Health and Safety
11. Residuals Management

raw analytical data to a form useful for interpretation. The most helpful are methods of graphical interpretation based on known physical or chemical phenomena or common practice (e.g., plotting concentrations of metal remaining in solution versus pH or chemical dosage).

- *Health and Safety*–Modify the site health and safety plan as needed to account for waste handling and onsite testing operations.

- *Residual Management*–Describe the types of residuals anticipated and how they will be managed.

5.5.2 Pilot-Scale Treatability Work Plan

Table 5-6 contains a suggested work plan format. Although many of the sections are similar to those of the bench-scale work plan format, differences between the two are discussed below.

Table 5-6. Suggested Format for Pilot-Scale Work Plan

1. Project Description and Site Background
2. Remedial Technology Description
3. Test Objectives
4. Pilot Plant Installation and Startup
5. Pilot Plant Operation and Maintenance Procedures
6. Parameters to be Tested
7. Sampling Plan
8. Analytical Methods
9. Data Management
10. Data Analysis and Interpretation
11. Health and Safety
12. Residuals Management

- *Pilot Plant Installation and Startup* – For onsite pilot studies, describe the equipment required and method to be employed to get the equipment onsite and installed for the test period.

- *Pilot Plant Operation and Maintenance Procedures* – Describe the specific conditions under which the pilot test will be conducted. Pilot plants are normally run with relatively large volumes of waste to simulate full-scale operation and, therefore, waste characteristics usually have to be measured and operating controls adjusted (e.g., chemical feed rates) to match instructions for startup and shutdown of the pilot plant. These specifications need to be included in the procedures list.

- *Parameters to be Tested* – List the operating conditions under which the pilot units are to be tested and the variations in control parameters that are to be evaluated (e.g., chemical feed rates or pH set points in a chemical precipitation test, or combustion temperature or gas residence time for an incinerator test).

- *Sampling Plan* – Describe locations and a schedule for samples to be taken from the pilot plant to determine performance; readings from in-line instruments, such as pH probes and sampling methods, containers, preservative, labeling, etc., should be included.

- *Health and Safety Plan* – Health and safety concerns are more critical during pilot tests because larger amounts of waste are involved and equipment is more complex. Equipment design and construction must comply with applicable code requirements.

5.6 Application of Results

5.6.1 Data Analysis and Interpretation

Following the completion of the treatability testing, results are reduced to a useful in accordance with the work plan. Data are interpreted on the technology's effectiveness, implementability, and/or cost, and anticipated results are compared with actual results. Graphical techniques are frequently used to present the results. Note that the level of reliability of the test results is usually based on the accuracy of the analytical methods employed.

Major differences between the anticipated and actual results may necessitate a modification of the work plan and retesting of the technology. In addition, raw-waste and effluent characteristics as well as by-products and emissions are evaluated to predict the ability of a full-scale unit to respond to variations in waste composition and meet performance specifications.

5.6.2 Use of the Results in the RI/FS Process

The purpose of a treatability evaluation is to provide information needed for the detailed analysis of alternatives and to allow selection of a remedial action to be made with a reasonable certainty of achieving the response objectives. All results are useful, even negative ones, because they can be used to eliminate technologies for further consideration. The results of bench and pilot tests can be used to ensure that conventional and innovative treatment or destruction technologies can be evaluated equally with nontreatment alternatives during the detailed analysis phase of the FS. Secondary use of treatability results provides information for the subsequent detailed design of the selected remedial technology. Operating conditions must be carefully and completely documented so that this information can be used in the full-scale system.

The characteristics of residuals from the remedial technology should be determined during pilot testing. This information is useful in determining how the residuals can be handled or disposed and in predicting the effects of their disposal or emission. Information can often be collected to determine if the residuals should be considered hazardous wastes or disposed of as a non-hazardous waste.

5.6.3 Scaling up to Full-Scale

The study findings need to be evaluated for application of the technology at full-scale; the limitations of the bench- or pilot-scale test (size, wall, and boundary effects, etc.) need to be compensated for. Scale-up can be done on the basis of either previous experience with the treatment equipment with other wastes or established rules of similitude (used to relate physical laws to variations in scale) and mathematical models. This evaluation may include a sensitivity analysis to identify the key parameters and unknowns that can affect a full-scale system. The potential need for process modifications during design or operation must be considered.

5.7 Community Relations During Treatability Investigations

Treatability testing is potentially controversial within a community and, therefore, additional community relations activities may be required. An assessment of issues and concerns the community may have about planned treatability testing should be conducted. The assessment should augment the previously prepared community relations plan (if treatability testing was not part of the original work plan) and should include a discussion of any issues unique to the proposed procedures such as onsite pilot testing, transporting contaminated materials offsite, schedule changes resulting from conducting bench or pilot tests, disposal of residuals, uncertainties pertaining to innovative technologies, and the degree of development of the technology being tested.

Additional community relations implementation activities may be recommended in the assessment and may include a public meeting to explain the proposed bench or pilot test, a fact sheet describing the technology and proposed test, a briefing to public officials about the treatability studies, and small group consultations with members of the community concerned about EPA's actions at the site. Other community relations activities may be needed, and consultations between the lead agency's project manager and the community relations coordinator should be used to establish the appropriate community relations activities.

5.8 Reporting and Communication During Treatability Investigations

Deliverables for the treatability investigations are listed in Table 5-7 and include the following:

- Revised work plans, as necessary, including bench and/or pilot tests
- Revised QAPP/FSP, as necessary
- Test results and evaluation report

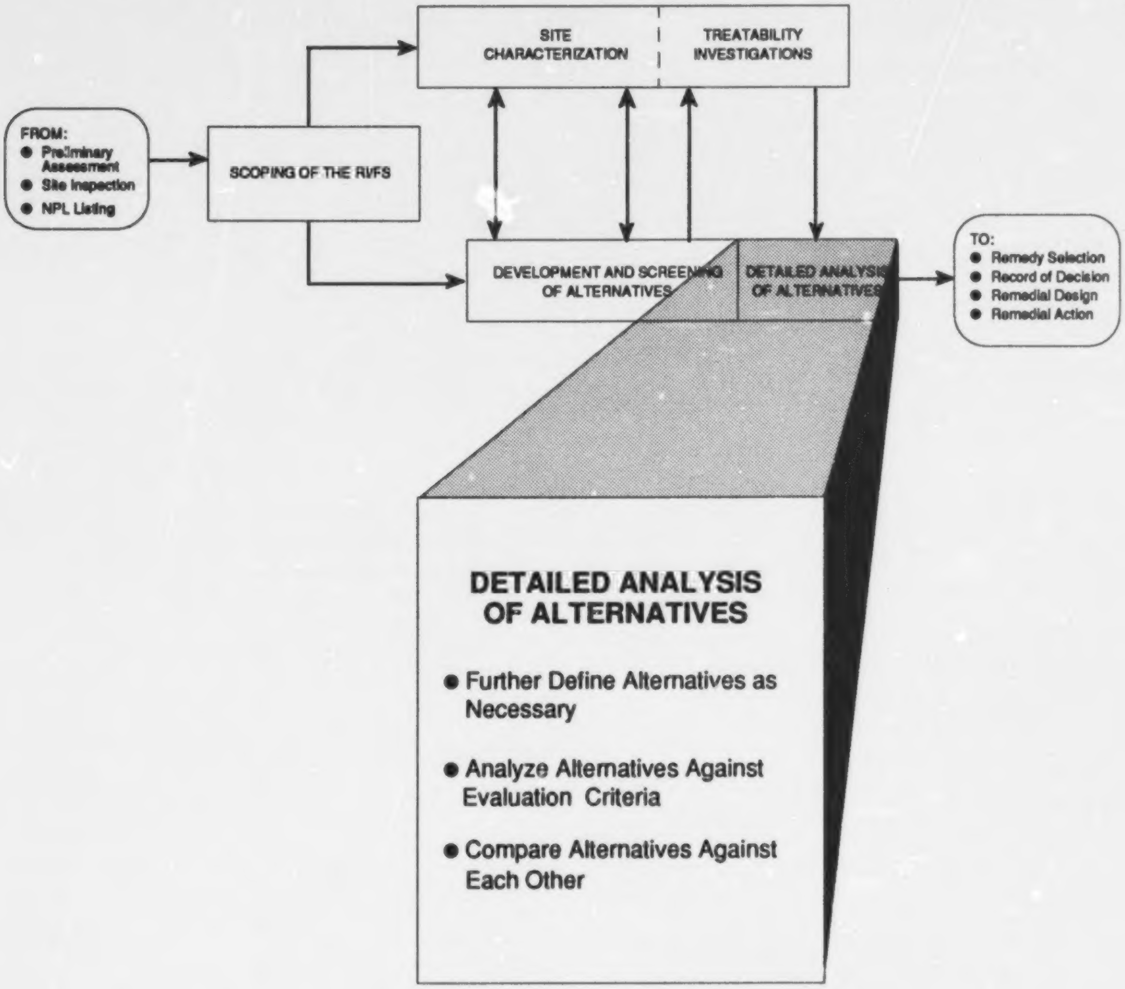
Table 5-7. Reporting and Communication During Treatability Investigations

Information Needed	Purpose	Potential Method for Information Provision
Need for Treatability Testing	For lead agency and contractor to determine whether more cost and performance data are needed to evaluate alternatives and select remedy; for lead agency to obtain support agency review and comment	Meeting Tech Memo
Approval of Site Data Collection or Treatability Testing	Obtain lead agency approval of treatability activities	QAPP (revised) FSP Treatability Study Work Plan

The treatability test evaluation report should describe the testing that was performed, the results of the tests, and an interpretation of how the results would affect the evaluation of the remedial alternatives being considered for the site. Effectiveness of the treatment technology for the wastes on the site should be presented. This report should also contain an evaluation of how the test results would affect treatment costs developed during the detailed analysis of alternatives (e.g., chemical requirements or settling rates required for effective treatment). Because the report may be used as an information source by other EPA and contractor staff at other sites with similar characteristics, it should be written clearly and concisely.

CHAPTER 6

DETAILED ANALYSIS OF ALTERNATIVES


FROM:
Preliminary Assessment
Site Inspection
NPL Listing
SCOPING OF THE RI/FS
SITE CHARACTERIZATION
TREATABILITY INVESTIGATIONS
DEVELOPMENT AND SCREENING OF ALTERNATIVES
DETAILED ANALYSIS OF ALTERNATIVES
TO:
Remedy Selection
Record of Decision
Remedial Design
Remedial Action
DETAILED ANALYSIS OF ALTERNATIVES
Further Define Alternatives as Necessary
Analyze Alternatives Against Evaluation Criteria
Compare Alternatives Against Each Other

Chapter 6

Detailed Analysis of Alternatives

6.1 Introduction

6.1.1 Pupose of the Detailed Analysis of Alternatives

The detailed analysis of alternatives consists of the analysis and presentation of the relevant information needed to allow decisionmakers to select a site remedy, not the decisionmaking process itself. During the detailed analysis, each alternative is assessed against the evaluation criteria described in this chapter. The results of this assessment are arrayed to compare the alternatives and identify the key tradeoffs among them. This approach to analyzing alternatives is designed to provide decisionmakers with sufficient information to adequately compare the alternatives, select an appropriate remedy for a site, and demonstrate satisfaction of the CERCLA remedy selection requirements in the ROD.

The specific statutory requirements for remedial actions that must be addressed in the ROD and supported by the FS report are listed below. Remedial actions must:

- Be protective of human health and the environment
- Attain ARARs (or provide grounds for invoking a waiver)
- Be cost-effective
- Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element or provide an explanation in the ROD as to why it does not

In addition, CERCLA places an emphasis on evaluating long-term effectiveness and related considerations for each of the alternative remedial actions (§121(b)(1)(A)). These statutory considerations include:

A) the long-term uncertainties associated with land disposal;

B) the goals, objectives, and requirements of the Solid Waste Disposal Act;

C) the persistence, toxicity, and mobility of hazardous substances and their constituents, and their propensity to bioaccumulate;

D) short- and long-term potential for adverse health effects from human exposure;

E) long-term maintenance costs;

F) the potential for future remedial action costs if the alternative remedial action in question were to fail; and

G) the potential threat to human health and the environment associated with excavation, transportation, and redisposal, or containment.

Nine evaluation criteria have been developed to address the CERCLA requirements and considerations listed above, and to address the additional technical and policy considerations that have proven to be important for selecting among remedial alternatives. These evaluation criteria serve as the basis for conducting the detailed analyses during the FS and for subsequently selecting an appropriate remedial action. The evaluation criteria with the associated statutory considerations are:

- Overall protection of human health and the environment
- Compliance with ARARs (B)
- Long-term effectiveness and permanence (A,B,C,D,F,G)
- Reduction of toxicity, mobility, or volume (B,C)
- Short-term effectiveness (D,G)
- Implementability

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- Cost (E,F)
- State acceptance (relates to Section 121(f))
- Community acceptance (relates to Sections 113 and 117)

6.1.2 *The Context of Detailed Analysis*

The detailed analysis of alternatives follows the development and screening of alternatives and precedes the actual selection of a remedy. As discussed in Chapter 4, the phases of the FS may overlap, with one beginning before another is completed, or they may vary in the level of detail based on the complexity or scope of the problem. The extent to which alternatives are analyzed during the detailed analysis is influenced by the available data, the number and types of alternatives being analyzed, and the degree to which alternatives were previously analyzed during their development and screening.

The evaluations conducted during the detailed analysis phase build on previous evaluations conducted during the development and screening of alternatives. This phase also incorporates any treatability study data and additional site characterization information that may have been collected during the RI.

The results of the detailed analysis provide the basis for identifying a preferred alternative and preparing the proposed plan. Upon completion of the detailed analysis, the FS report, along with the proposed plan (and the RI report if not previously released), is submitted for public review and comment. The results of the detailed analysis supports the final selection of a remedial action and the foundation for the Record of Decision.

6.1.3 *Overview of the Detailed Analysis*

A detailed analysis of alternatives consists of the following components:

- Further definition of each alternative, if necessary, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies
- An assessment and a summary profile of each alternative against the evaluation criteria
- A comparative analysis among the alternatives to assess the relative performance of each alternative with respect to each evaluation criterion

Figure 6-1 illustrates the steps in the detailed analysis process.

6.2 Detailed Analysis of Alternatives

6.2.1 *Alternative Definition*

Alternatives are defined during the development and screening phase (see Chapter 4) to match contaminated media with appropriate process options.[1] However, the alternatives selected as the most promising may need to be better defined during the detailed analysis. Each alternative should be reviewed to determine if an additional definition is required to apply the evaluation criteria consistently and to develop order-of-magnitude cost estimates (i.e., having a desired accuracy of +50 percent to -30 percent). The information developed to define alternatives at this stage in the RI/FS process may consist of preliminary design calculations, process flow diagrams, sizing of key process components, preliminary site layouts, and a discussion of limitations, assumptions, and uncertainties concerning each alternative. The following examples illustrate situations in which additional alternative definition is appropriate:

- The assumed sizing of the process option must be revised on the basis of results of treatability data (e.g., a taller air stripping tower with more packing is required to attain the treatment target).
- A different process option is to be used to represent the technology type on the basis of the results of treatability data (e.g., activated carbon rather than air stripping is required).
- The estimated volume of contaminated media has been refined on the basis of additional site characterization data.

As described in Chapter 4, alternatives can be developed and screened on a medium-specific or sitewide basis at the lead agency's discretion. Although it is acceptable to continue the evaluation of alternatives on a medium-specific basis during the detailed analysis, it is encouraged that alternatives be configured to present the decision-maker with a range of discrete options each of which addresses the entire site or operable unit being addressed by the FS.[2] Therefore, if separate alternatives have been developed for different areas or media of the site, it is recommended that they be combined during the detailed analysis phase to present comprehensive

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[1] This matching is done by identifying specific remedial action objectives (e.g., a risk-based cleanup target such as $1x10^{-6}$) and sizing process options to attain the objective (e.g., 10 ground-water extraction wells extracting 50 gpm each, activated carbon treatment for 500 gpm).

[2] This approach will better facilitate and simplify the nine criteria evaluation and preparation of a rationale for remedy selection in the Record of Decision.

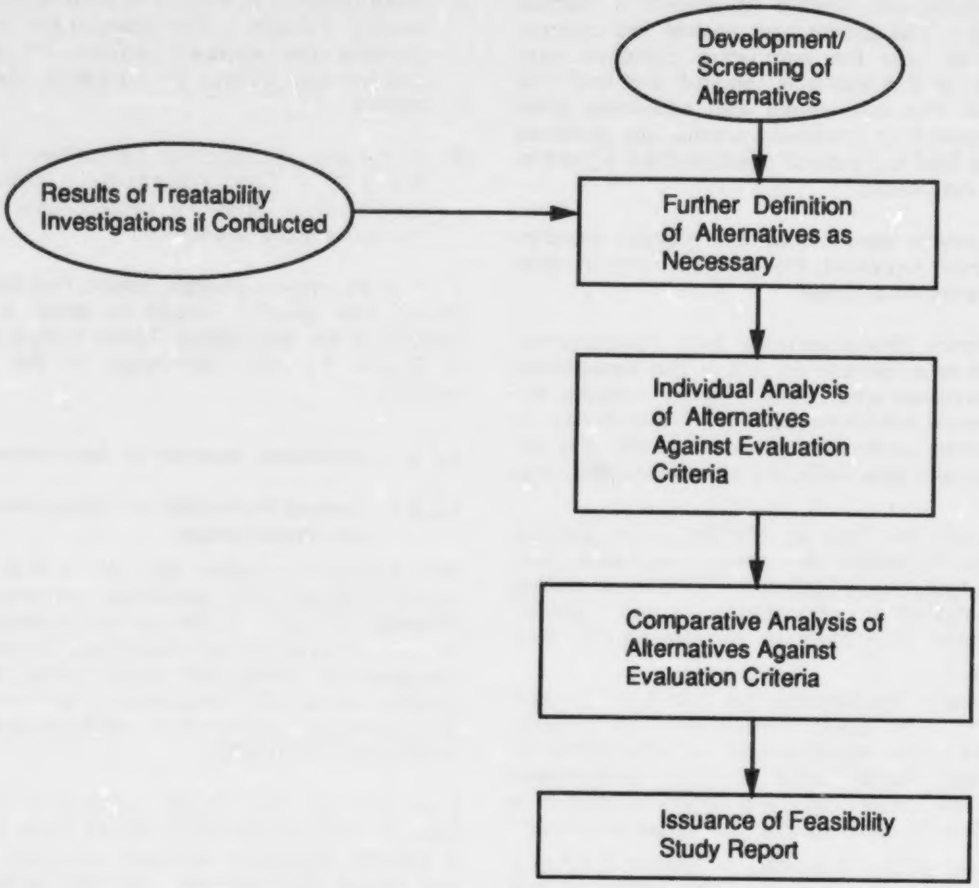
Development/ Screening of Alternatives
Results of Treatability Investigations if Conducted
Further Definition of Alternatives as Necessary
Individual Analysis of Alternatives Against Evaluation Criteria
Comparative Analysis of Alternatives Against Evaluation Criteria
Issuance of Feasibility Study Report

Figure 6-1. Detailed analysis of alternatives.

options addressing all potential threats posed by the site or that area being addressed by the operable unit. This can be accomplished either at the beginning of the detailed analysis or following the individual analysis when the alternatives are summarized and a comparative analysis is performed.

6.2.2 *Overview of Evaluation Criteria*

The detailed analysis provides the means by which facts are assembled and evaluated to develop the rationale for a remedy selection. Therefore, it is necessary to understand the requirements of the remedy selection process to ensure that the FS analysis provides the sufficient quantity and quality of information to simplify the transition between the FS report and the actual selection of a remedy. The analytical process described here has been developed on the basis of statutory requirements of CERCLA Section 121 (see Section 6.1.1); earlier program initiatives promulgated in the November 20, 1985, National Contingency Plan; and site-specific experience gained in the Superfund program. The nine evaluation criteria listed in Section 6.1.1 encompass statutory requirements and technical, cost, and institutional considerations the program has determined appropriate for a thorough evaluation.

Assessments against two of the criteria relate directly to statutory findings that must ultimately be made in the ROD. Therefore, these are categorized as threshold criteria in that each alternative must meet them.[3] These two criteria are briefly described below:

- Overall Protection of Human Health and the Environment (described in Section 6.2.3.1) – The assessment against this criterion describes how the alternative, as a whole, achieves and maintains protection of human health and the environment.

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[3] The ultimate determination and declaration that these findings can be made of the selected remedy is contained in the ROD.

- Compliance with ARARs (described in Section 6.2.3.2) – The assessment against this criterion describes how the alternative complies with ARARs, or if a waiver is required and how it is justified. The assessment also addresses other information from advisories, criteria, and guidance that the lead and support agencies have agreed is "to be considered."

The five criteria listed below are grouped together because they represent the primary criteria upon which the analysis is based.

- Long-term Effectiveness and Permanence (described in Section 6.2.3.3) – The assessment of alternatives against this criterion evaluates the long-term effectiveness of alternatives in maintaining protection of human health and the environment after response objectives have been met.
- Reduction of Toxicity, Mobility, and Volume Through Treatment (described in Section 6.2.3.4) – The assessment against this criterion evaluates the anticipated performance of the specific treatment technologies an alternative may employ.
- Short-term Effectiveness (described in Section 6.2.3.5) – The assessment against this criterion examines the effectiveness of alternatives in protecting human health and the environment during the construction and implementation of a remedy until response objectives have been met.
- Implementability (described in Section 6.2.3.6) – This assessment evaluates the technical and administrative feasibility of alternatives and the availability of required goods and services.
- Cost (described in Section 6.2.3.7) – This assessment evaluates the capital and operation and maintenance (O&M) costs of each alternative.

The level of detail required to analyze each alternative against these evaluation criteria will depend on the type and complexity of the site, the type of technologies and alternatives being considered, and other project-specific considerations. The analysis should be conducted in sufficient detail so that decisionmakers understand the significant aspects of each alternative and any uncertainties associated with the evaluation (e.g., a cost estimate developed on the basis of a volume of media that could not be defined precisely).

The final two criteria, state or support agency acceptance and community acceptance, will be evaluated following comment on the RI/FS report and the proposed plan and will be addressed once a final decision is being made and the ROD is being prepared. The criteria are as follows:

- State (Support Agency) Acceptance (described in Section 6.2.3.8) – This assessment reflects the state's (or support agency's) apparent preferences among or concerns about alternatives.
- Community Acceptance (described in Section 6.2.3.9) – This assessment reflects the community's apparent preferences among or concerns about alternatives.

Each of the nine evaluation criteria has been further divided into specific factors to allow a thorough analysis of the alternatives. These factors are shown in Figure 6-2 and discussed in the following sections.

6.2.3 *Individual Analysis of Alternatives*

6.2.3.1 Overall Protection of Human Health and the Environment

This evaluation criterion provides a final check to assess whether each alternative provides adequate protection of human health and the environment. The overall assessment of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Evaluation of the overall protectiveness of an alternative during the RI/FS should focus on whether a specific alternative achieves adequate protection and should describe how site risks posed through each pathway being addressed by the FS are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. This evaluation also allows for consideration of whether an alternative poses any unacceptable short-term or cross-media impacts.

6.2.3.2 Compliance with ARARs

This evaluation criterion is used to determine whether each alternative will meet all of its Federal and State ARARs (as defined in CERCLA Section 121) that have been identified in previous stages of the RI/FS process. The detailed analysis should summarize which requirements are applicable or relevant and appropriate to an alternative[4] and describe how the alternative meets these requirements. When an ARAR is not met, the basis for justifying one of the six waivers allowed under CERCLA (see Section 1.2.1.1) should be discussed.

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[4] This effort will require input from the support agency.

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

- How Alternative Provides Human Health and Environmental Protection

COMPLIANCE WITH ARARs

- Compliance With Chemical-Specific ARARs
- Compliance With Action-Specific ARARs
- Compliance With Location-Specific ARARs
- Compliance With Other Criteria, Advisories, and Guidances

LONG-TERM EFFECTIVENESS AND PERMANENCE

- Magnitude of Residual Risk
- Adequacy and Reliability of Controls

REDUCTION OF TOXICITY MOBILITY, AND VOLUME THROUGH TREATMENT

- Treatment Process Used and Materials Treated
- Amount of Hazardous Materials Destroyed or Treated
- Degree of Expected Reductions in Toxicity, Mobility, and Volume
- Degree to Which Treatment Is Irreversible
- Type and Quantity of Residuals Remaining After Treatment

SHORT-TERM EFFECTIVENESS

- Protection of Community During Remedial Actions
- Protection of Workers During Remedial Actions
- Environmental Impacts
- Time Until Remedial Action Objectives Are Achieved

IMPLEMENTABILITY

- Ability to Construct and Operate the Technology
- Reliability of the Technology
- Ease of Undertaking Additional Remedial Actions, if Necessary
- Ability to Monitor Effectiveness of Remedy
- Ability to Obtain Approvals From Other Agencies
- Coordination With Other Agencies
- Availability of Offsite Treatment, Storage, and Disposal Services and Capacity
- Availability of Necessary Equipment and Specialists
- Availability of Prospective Technologies

COST

- Capital Costs
- Operating and Maintenance Costs
- Present Worth Cost

STATE[1] ACCEPTANCE

COMMUNITY[1] ACCEPTANCE

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[1] These criteria are assessed following comment on the RI/FS report and the proposed plan.

Figure 6-2. Criteria for detailed analysis of alternatives.

The following should be addressed for each alternative during the detailed analysis of ARARs:[5]

- Compliance with chemical-specific ARARs (e.g., maximum contaminant levels) – This factor addresses whether the ARARs can be met, and if not, whether a waiver is appropriate.
- Compliance with location-specific ARARs (e.g., preservation of historic sites) – As with other ARAR-related factors, this involves a

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[5] Other available information that is not an ARAR (e.g., advisories, criteria, and guidance) may be considered in the analysis if it helps to ensure protectiveness or is otherwise appropriate for use in a specific alternative. These TBC materials should be included in the detailed analysis if the lead and support agencies agree that their inclusion is appropriate.

consideration of whether the ARARs can be met or whether a waiver is appropriate.

- Compliance with action-specific ARARs (e.g., RCRA minimum technology standards) – It must be determined whether ARARs can be met or will be waived.

The actual determination of which requirements are applicable or relevant and appropriate is made by the lead agency in consultation with the support agency. A summary of these ARARs and whether they will be attained by a specific alternative should be presented in an appendix to the RI/FS report. A suggested format for this summary is provided in Appendix E of this guidance. More detailed guidance on determining whether requirements are applicable or relevant and appropriate is provided in the "CERCLA Compliance with Other Laws Manual" (U.S. EPA, Draft, May 1988).

6.2.3.3 Long-term Effectiveness and Permanence

The evaluation of alternatives under this criterion addresses the results of a remedial action in terms of the risk remaining at the site after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. The following components of the criterion should be addressed for each alternative:

- Magnitude of residual risk – This factor assesses the residual risk remaining from untreated waste or treatment residuals at the conclusion of remedial activities, (e.g., after source/soil containment and/or treatment are complete, or after ground-water plume management activities are concluded). The potential for this risk may be measured by numerical standards such as cancer risk levels or the volume or concentration of contaminants in waste, media, or treatment residuals remaining on the site. The characteristics of the residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

- Adequacy and reliability of controls – This factor assesses the adequacy and suitability of controls, if any, that are used to manage treatment residuals or untreated wastes that remain at the site. It may include an assessment of containment systems and institutional controls to determine if they are sufficient to ensure that any exposure to human and environmental receptors is within protective levels. This factor also addresses the long-term reliability of management controls for providing continued protection from residuals. It includes the assessment of the potential need to replace technical components of the alternative, such as a cap, a slurry wall, or a treatment system; and the potential exposure pathway and the risks posed should the remedial action need replacement.

Table 6-1 lists appropriate questions that may need to be addressed during the analysis of long-term effectiveness.

6.2.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

This evaluation criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances as their principal element. This preference is satisfied when treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media.

This evaluation would focus on the following specific factors for a particular remedial alternative:

- The treatment processes the remedy will employ, and the materials they will treat

- The amount of hazardous materials that will be destroyed or treated, including how the principal threat(s) will be addressed

- The degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction (or order of magnitude)

- The degree to which the treatment will be irreversible

- The type and quantity of treatment residuals that will remain following treatment

- Whether the alternative would satisfy the statutory preference for treatment as a principal element[6]

In evaluating this criterion, an assessment should be made as to whether treatment is used to reduce principal threats, including the extent to which toxicity, mobility, or volume are reduced either alone or in

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[6] It may be that alternatives for limited actions (e.g., provision of an alternative water supply) will not address principal threats within their narrow scope.

Table 6-1. Long-Term Effectiveness and Permanence

Analysis Factor	Specific Factor Considerations
Magnitude of residual risks	• What is the magnitude of the remaining risks?
	• What remaining sources of risk can be identified? How much is due to treatment residuals, and how much is due to untreated residual contamination?
	• Will a 5-year review be required?
Adequacy and reliability of controls	• What is the likelihood that the technologies will meet required process efficiencies or performance specifications?
	• What type and degree of long-term management is required?
	• What are the requirements for long- term monitoring?
	• What operation and maintenance functions must be performed?
	• What difficulties and uncertainties may be associated with long-term operation and maintenance?
	• What is the potential need for replacement of technical components?
	• What is the magnitude of the threats or risks should the remedial action need replacement?
	• What is the degree of confidence that controls can adequately handle potential problems?
	• What are the uncertainties associated with land disposal of residuals and untreated wastes?

combination. Table 6-2 lists typical questions that may need to be addressed during the analysis of toxicity, mobility, or volume reduction.

6.2.3.5 Short-term Effectiveness

This evaluation criterion addresses the effects of the alternative during the construction and implementation phase until remedial response objectives are met (e.g., a cleanup target has been met). Under this criterion, alternatives should be evaluated with respect to their effects on human health and the environment during implementation of the remedial action. The following factors should be addressed as appropriate for each alternative:

- Protection of the community during remedial actions – This aspect of short-term effectiveness addresses any risk that results from implementation of the proposed remedial action, such as dust from excavation, transportation of hazardous materials, or air-quality impacts from a stripping tower operation that may affect human health.

- Protection of workers during remedial actions – This factor assesses threats that may be posed to workers and the effectiveness and reliability of protective measures that would be taken.

- Environmental impacts – This factor addresses the potential adverse environmental impacts that may result from the construction and implementation of an alternative and evaluates the reliability of the available mitigation measures in preventing or reducing the potential impacts.

- Time until remedial response objectives are achieved – This factor includes an estimate of the time required to achieve protection for either the entire site or individual elements associated with specific site areas or threats.

Table 6-3 lists appropriate questions that may need to be addressed during the analysis of short-term effectiveness.

6.2.3.6 Implementability

The implementability criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. This criterion involves analysis of the following factors:

- Technical feasibility
  - Construction and operation – This relates to the technical difficulties and unknowns associated with a technology. This was initially identified for specific technologies during the development and screening of alternatives and is addressed again in the detailed analysis for the alternative as a whole.
  - Reliability of technology – This focuses on the likelihood that technical problems associated with implementation will lead to schedule delays.
  - Ease of undertaking additional remedial action – This includes a discussion of what, if any, future remedial actions may need to be undertaken and how difficult it would be to implement such additional actions. This is particularly applicable for an FS addressing an interim action at a site where additional operable units may be analyzed at a later time.

Table 6-2. Reduction of Toxicity, Mobility, or Volume Through Treatment

Analysis Factor	Specific Factor Considerations
Treatment process and remedy	• Does the treatment process employed address the principal threats? • Are there any special requirements for the treatment process?
Amount of hazardous material destroyed or treated	• What portion (mass, volume) of contaminated material is destroyed? • What portion (mass, volume) of contaminated material is treated?
Reduction in toxicity, mobility, or volume	• To what extent is the total mass of toxic contaminants reduced? • To what extent is the mobility of toxic contaminants reduced? • To what extent is the volume of toxic contaminants reduced?
Irreversibility of the treatment	• To what extent are the effects of treatment irreversible?
Type and quantity of treatment residual	• What residuals remain? • What are their quantities and characteristics? • What risks do treatment residuals pose?
Statutory preference for treatment as a principal element	• Are principal threats within the scope of the action? • Is treatment used to reduce inherent hazards posed by principal threats at the site?

Table 6-3. Short-Term Effectiveness

Analysis Factor	Basis for Evaluation During Detailed Analysis
Protection of community during remedial actions	• What are the risks to the community during remedial actions that must be addressed? • How will the risks to the community be addressed and mitigated? • What risks remain to the community that cannot be readily controlled?
Protection of workers during remedial actions	• What are the risks to the workers that must be addressed? • What risks remain to the workers that cannot be readily controlled? • How will the risks to the workers be addressed and mitigated?
Environmental impacts	• What environmental impacts are expected with the construction and implementation of the alternative? • What are the available mitigation measures to be used and what is their reliability to minimize potential impacts? • What are the impacts that cannot be avoided should the alternative be implemented?
Time until remedial response objectives are achieved	• How long until protection against the threats being addressed by the specific action is achieved? • How long until any remaining site threats will be addressed? • How long until remedial response objectives are achieved?

  - Monitoring considerations – This addresses the ability to monitor the effectiveness of the remedy and includes an evaluation of the risks of exposure should monitoring be insufficient to detect a system failure.

- Administrative feasibility
  - Activities needed to coordinate with other offices and agencies (e.g., obtaining permits for offsite activities or rights-of-way for construction)
- Availability of services and materials
  - Availability of adequate offsite treatment, storage capacity, and disposal services
  - Availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources
  - Availability of services and materials, plus the potential for obtaining competitive bids, which may be particularly important for innovative technologies
  - Availability of prospective technologies

Table 6-4 lists typical questions that may need to be addressed during the analysis of implementability.

6.2.3.7 Cost

A comprehensive discussion of costing procedures for CERCLA sites is contained in the *Remedial Action*

Table 6-4. Implementability

Analysis Factor	Specific Factor Considerations
Technical Feasibility	
Ability to construct and operate technology	• What difficulties may be associated with construction? • What uncertainties are related to construction?
Reliability of technology	• What is the likelihood that technical problems will lead to schedule delays?
Ease of undertaking additional remedial action, if necessary	• What likely future remedial actions may be anticipated? • How difficult would it be to implement the additional remedial actions, if required?
Monitoring considerations	• Do migration or exposure pathways exist that cannot be monitored adequately? • What risks of exposure exist should monitoring be insufficient to detect failure?
Administrative Feasibility	
Coordination with other agencies	• What steps are required to coordinate with other agencies? • What steps are required to set up long-term or future coordination among agencies? • Can permits for offsite activities be obtained if required?
Availability of Services and Materials	
Availability of treatment,storage capacity, and disposal services	• Are adequate treatment, storage capacity, and disposal services available? • How much additional capacity is necessary? • Does the lack of capacity prevent implementation? • What additional provisions are required to ensure the needed additional capacity?
Availability of necessary equipment and specialists	• Are the necessary equipment and specialists available? • What additional equipment and specialists are required? • Does the lack of equipment and specialists prevent implementation? • What additional provisions are required to ensure the needed equipment and specialists?
Availability of prospective technologies	• Are technologies under consideration generally available and sufficiently demonstrated for the specific application? • Will technologies require further development before they can be applied full-scale to the type of waste at the site? • When should the technology be available for full-scale use? • Will more than one vendor be available to provide a competitive bid?

Costing Procedures Manual (U.S. EPA, September 1985). The application of cost estimates to the detailed analysis is discussed in the following paragraphs.

Capital Costs. Capital costs consist of direct (construction) and indirect (nonconstruction and overhead) costs. Direct costs include expenditures for the equipment, labor, and materials necessary to install remedial actions. Indirect costs include expenditures for engineering, financial, and other services that are not part of actual installation activities but are required to complete the installation of remedial alternatives. (Sales taxes normally do not apply to Superfund actions.) Costs that must be incurred in the future as part of the remedial action alternative should be identified and noted for the year in which they will occur. The distribution of costs over time will be a critical factor in making tradeoffs between capital-intensive technologies (including alternative treatment and destruction technologies) and less capital-intensive technologies (such as pump and treatment systems).

Direct capital costs may include the following:

- Construction costs – Costs of materials, labor and equipment required to install a remedial action
- Equipment costs – Costs of remedial action and service equipment necessary to enact the remedy (these materials remain until the site remedy is complete)
- Land and site-development costs – Expenses associated with the purchase of land and the site preparation costs of existing property
- Buildings and services costs – Costs of process and nonprocess buildings, utility connections, purchased services, and disposal costs
- Relocation expenses – Costs of temporary or permanent accommodations for affected nearby

residents. (Since cost estimates for relocations can be complicated, FEMA authorities and EPA Headquarters should be consulted in estimating these costs.)

- Disposal costs - Costs of transporting and disposing of waste material such as drums and contaminated soils

Indirect capital costs may include:

- Engineering expenses - Costs of administration, design, construction supervision, drafting, and treatability testing
- License or permit costs - Administrative and technical costs necessary to obtain licenses and permits for installation and operation of offsite activities
- Startup and shakedown costs - Costs incurred to ensure system is operational and functional
- Contingency allowances - Funds to cover costs resulting from unforeseen circumstances, such as adverse weather conditions, strikes, or contaminant not detected during site characterization

Annual O&M Costs. Annual O&M costs are post-construction costs necessary to ensure the continued effectiveness of a remedial action. The following annual O&M cost components should be considered:

- Operating labor costs - Wages, salaries, training, overhead, and fringe benefits associated with the labor needed for post-construction operations
- Maintenance materials and labor costs - Costs for labor, parts, and other resources required for routine maintenance of facilities and equipment
- Auxiliary materials and energy - Costs of such items as chemicals and electricity for treatment plant operations, water and sewer services, and fuel
- Disposal of residues - Costs to treat or dispose of residuals such as sludges from treatment processes or spent activated carbon
- Purchased services - Sampling costs, laboratory fees, and professional fees for which the need can be predicted
- Administrative costs - Costs associated with the administration of remedial O&M not included under other categories
- Insurance, taxes, and licensing costs - Costs of such items as liability and sudden accidental insurance; real estate taxes on purchased land or rights-of-way; licensing fees for certain technologies; and permit renewal and reporting costs
- Maintenance reserve and contingency funds - Annual payments into escrow funds to cover costs of anticipated replacement or rebuilding of equipment and any large unanticipated O&M costs
- Rehabilitation costs - Cost for maintaining equipment or structures that wear out over time
- Costs of periodic site reviews - Costs for site reviews that are conducted at least every 5 years if wastes above health-based levels remain at the site

The costs of potential future remedial actions should be addressed, and if appropriate, should be included when there is a reasonable expectation that a major component of the alternative will fail and require replacement to prevent significant exposure to contaminants. Analyses described under Section 6.2.3.3, "Long-term Effectiveness and Permanence," should be used to determine which alternatives may result in future costs. It is not expected that a detailed statistical analysis will be required to identify probable future costs. Rather, qualitative engineering judgment should be used and the rationale documented in the FS report.

Accuracy of Cost Estimates. Site characterization and treatability investigation information should permit the user to refine cost estimates for remedial action alternatives. It is important to consider the accuracy of costs developed for alternatives in the FS. Typically, these "study estimate" costs made during the FS are expected to provide an accuracy of +50 percent to -30 percent and are prepared using data available from the RI. It should be indicated when it is not realistic to achieve this level of accuracy.

Present Worth Analysis. A present worth analysis is used to evaluate expenditures that occur over different time periods by discounting all future costs to a common base year, usually the current year. This allows the cost of remedial action alternatives to be compared on the basis of a single figure representing the amount of money that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life.

In conducting the present worth analysis, assumptions must be made regarding the discount rate and the period of performance. The Superfund program recommends that a discount rate of 5 percent before taxes and after inflation be assumed. Estimates of costs in each of the planning years are made in constant dollars, representing the general purchasing power at the time of construction. In general, the period of performance for costing purposes should not exceed 30 years for the purpose of the detailed analysis.

Cost Sensitivity Analysis. After the present worth of each remedial action alternative is calculated, individual costs may be evaluated through a sensitivity analysis if there is sufficient uncertainty concerning specific assumptions. A sensitivity analysis assesses the effect that variations in specific assumptions associated with the design, implementation, operation, discount rate, and effective life of an alternative can have on the estimated cost of the alternative. These assumptions depend on the accuracy of the data developed during the site characterization and treatability investigation and on predictions of the future behavior of the technology. Therefore, these assumptions are subject to varying degrees of uncertainty from site to site. The potential effect on the cost of an alternative because of these uncertainties can be observed by varying the assumptions and noting the effects on estimated costs. Sensitivity analyses can also be used to optimize the design of a remedial action alternative, particularly when design parameters are interdependent (e.g., treatment plant capacity for contaminated ground water and the length of the period of performance).

Use of sensitivity analyses should be considered for the factors that can significantly change overall costs of an alternative with only small changes in their values, especially if the factors have a high degree of uncertainty associated with them. Other factors chosen for analysis may include those factors for which the expected (or estimated) value is highly uncertain. The results of such an analysis can be used to identify worst-case scenarios and to revise estimates of contingency or reserve funds.

The following factors are potential candidates for consideration in conducting a sensitivity analysis:

- The effective life of a remedial action
- The O&M costs
- The duration of cleanup
- The volume of contaminated material, given the uncertainty about site conditions
- Other design parameters (e.g., the size of the treatment system)
- The discount rate (5 percent should be used to compare alternative costs, however, a range of 3 to 10 percent can be used to investigate uncertainties)

The results of a sensitivity analysis should be discussed during the comparison of alternatives. Areas of uncertainty that may have a significant effect on the cost of an alternative should be highlighted, and a rationale should be presented for selection of the most probable value of the parameter.

6.2.3.8 State (Support Agency) Acceptance

This assessment evaluates the technical and administrative issues and concerns the state (or support agency in the case of State-lead sites) may have regarding each of the alternatives. As discussed earlier, this criterion will be addressed in the ROD once comments on the RI/FS report and proposed plan have been received.

6.2.3.9 Community Acceptance

This assessment evaluates the issues and concerns the public may have regarding each of the alternatives. As with state acceptance, this criterion will be addressed in the ROD once comments on the RI/FS report and proposed plan have been received.

6.2.4 *Presentation of Individual Analysis*

The analysis of individual alternatives with respect to the specified criteria should be presented in the FS report as a narrative discussion accompanied by a summary table. This information will be used to compare the alternatives and support a subsequent analysis of the alternatives made by the decision-maker in the remedy selection process. The narrative discussion should, for each alternative, provide (1) a description of the alternative and (2) a discussion of the individual criteria assessment.

The alternative description should provide data on technology components (use of innovative technologies should be identified), quantities of hazardous materials handled, time required for implementation, process sizing, implementation requirements, and assumptions. These descriptions, by clearly articulating the various waste management strategies for each alternative, will also serve as the basis for documenting the rationale of the applicability or relevance and appropriateness of potential Federal and State requirements. Therefore, the significant ARARs for each alternative should be identified and integrated into these discussions.

The narrative discussion of the analysis should, for each alternative, present the assessment of the alternative against each of the criteria.[7] This discussion should focus on how, and to what extent, the various factors within each of the criteria are addressed.[8] The uncertainties associated with specific alternatives should be included when changes in assumptions or unknown conditions could affect the analysis (e.g., the time to attain ground-water cleanup targets may be twice as long as estimated if assumptions made about aquifer characteristics for a specific ground-water extraction alternative are incorrect.) An example of an individual analysis is presented in Appendix F.

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[7] As noted previously, State and community acceptance will be addressed in the ROD once comments have been received on the RI/FS report and proposed plan.

The FS also should include a summary table highlighting the assessment of each alternative with respect to each of the nine criteria. Appendix F provides an example of such a summary table.

6.2.5 *Comparative Analysis of Alternatives*

Once the alternatives have been described and individually assessed against the criteria, a comparative analysis should be conducted to evaluate the relative performance of each alternative in relation to each specific evaluation criterion. This is in contrast to the preceding analysis in which each alternative was analyzed independently without a consideration of other alternatives. The purpose of this comparative analysis is to identify the advantages and disadvantages of each alternative relative to one another so that the key tradeoffs the decisionmaker must balance can be identified.

Overall protection of human health and the environment and compliance with ARARs will generally serve as threshold determinations in that they must be met by any alternative in order for it to be eligible for selection. The next five criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, and volume through treatment; short-term effectiveness; implementability; and cost) will generally require the most discussion because the major tradeoffs among alternatives will most frequently relate to one or more of these five.

State and community acceptance will be addressed in the ROD once formal comments on the RI/FS report and the proposed plan have been received and a final remedy selection decision is being made.

6.2.6 *Presentation of Comparative Analysis*

The comparative analysis should include a narrative discussion describing the strengths and weaknesses of the alternatives relative to one another with respect to each criterion, and how reasonable variations of key uncertainties could change the expectations of their relative performance. An effective way of organizing this section is, under each individual criterion, to discuss the alternative(s) that performs the best overall in that category, with other alternatives discussed in the relative order in which they perform. If innovative technologies are being considered, their potential advantages in cost or performance and the degree of uncertainty in their expected performance (as compared with more demonstrated technologies) should also be discussed. Appendix F provides an example of a comparative analysis.

The presentation of differences among alternatives can be measured either qualitatively or quantitatively, as appropriate, and should identify substantive differences (e.g., greater short-term effectiveness concerns, greater cost, etc.). Quantitative information that was used to assess the alternatives (e.g., specific cost estimates, time until response objectives would be obtained, and levels of residual contamination) should be included in these discussions.

6.3 Post-RI/FS Selection of the Preferred Alternative

Following completion of the RI/FS, the results of the detailed analyses, when combined with the risk management judgments made by the decision-maker, become the rationale for selecting a preferred alternative and preparing the proposed plan. Therefore, the results of the detailed analysis, or more specifically the comparative analysis, should serve to highlight the relative advantages and disadvantages of each alternative so that the key tradeoffs can be identified. It will be these key tradeoffs coupled with risk management decisions that will serve as the basis for the rationale and provide a transition between the RI/FS report and the development of a proposed plan (and ultimately a ROD). Specific guidance for preparing proposed plans and RODs is provided in the draft guidance on preparing Superfund decision documents.

6.4 Community Relations During Detailed Analysis

Site-specific community relations activities should be identified in the community relations plan prepared previously. While appropriate modifications of activities may be made to the community relations plan as the project progresses, the plan should generally be implemented as written to ensure that the community is informed of the alternatives being evaluated and is provided a reasonable opportunity to provide input to the decision-making process.

Often, a fact sheet is prepared that summarizes the feasible alternatives being evaluated. As appropriate, small group consultations or public meetings may be held to discuss community concerns and explain alternatives under consideration. Public officials should be briefed and press releases prepared describing the alternatives. Other activities identified in the community relations plan should be implemented.

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[8] The factors presented in Tables 6-1 through 6-4 have been included to illustrate typical concerns that may need to be addressed during the detailed analysis. It will not be necessary or appropriate in all situations to address every factor in these tables for each alternative being evaluated. Under some circumstances, it may be useful to address other factors not presented in these tables to ensure a better understanding of how an alternative performs with respect to a particular criterion.

The objective of community relations during the detailed analysis is to assist the community in understanding the alternatives and the specific considerations the lead agency must take into account in selecting an alternative. In this way, the community is prepared to provide meaningful input during the upcoming public comment period.

6.5 Reporting and Communication During Detailed Analysis

Once the draft RI/FS report is prepared, the lead agency obtains the support agency's review and concurrence, the public's review and comment, and local agency and PRP input, if appropriate. The RI/FS report also provides a basis for remedy selection by EPA (or concurrence on State and Federal facility remedy) and documents the development and analysis of alternatives. A suggested FS report format is given in Table 6-5.

Table 6-5. Suggested FS Report Format

Executive Summary
1. Introduction
  - 1.1 Purpose and Organization of Report
  - 1.2 Background Information (Summarized from RI Report)
    - 1.2.1 Site Description
    - 1.2.2 Site History
    - 1.2.3 Nature and Extent of Contamination
    - 1.2.4 Contaminant Fate and Transport
    - 1.2.5 Baseline Risk Assessment
2. Identification and Screening of Technologies
  - 2.1 Introduction
  - 2.2 Remedial Action Objectives – Presents the development of remedial action objectives for each medium of interest (i.e., ground water, soil, surface water, air, etc.). For each medium, the following should be discussed:
    - – Contaminants of interest
    - – Allowable exposure based on risk assessment (including ARARs)
    - – Development of remediation goals
  - 2.3 General Response Actions – For each medium of interest, describes the estimation of areas or volumes to which treatment, containment, or exposure technologies may be applied.
  - 2.4 Identification and Screening of Technology Types and Process Options – For each medium of interest, describes:
    - 2.4.1 Identification and Screening of Technologies
    - 2.4.2 Evaluation of Technologies and Selection of Representative Technologies
3. Development and Screening of Alternatives
  - 3.1 Development of Alternatives – Describes rationale for combination of technologies/media into alternatives. Note: This discussion may be by medium or for the site as a whole.
  - 3.2 Screening of Alternatives (if conducted)
    - 3.2.1 Introduction
    - 3.2.2 Alternative 1
      - 3.2.2.1 Description
      - 3.2.2.2 Evaluation
    - 3.2.3 Alternative 2
      - 3.2.3.1 Description
      - 3.2.3.2 Evaluation
    - 3.2.4 Alternative 3
4. Detailed Analysis of Alternatives
  - 4.1 Introduction
  - 4.2 Individual Analysis of Alternatives
    - 4.2.1 Alternative 1
      - 4.2.1.1 Description
      - 4.2.1.2 Assessment
    - 4.2.2 Alternative 2
      - 4.2.2.1 Description
      - 4.2.2.2 Assessment
    - 4.2.3 Alternative 3
  - 4.3 Comparative Analysis

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Appendices

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Appendix A

Interim Guidance on PRP Participation in the RI/FS Process*

I. Introduction

This memorandum sets forth the policy and procedures governing the participation of potentially responsible parties (PRPs) in the development of remedial investigations (RI) and feasibility studies (FS) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. This memorandum discusses:

- The initiation of enforcement activities including PRP searches and PRP notification;
- The circumstances in which PRPs may conduct the RI/FS;
- The development of enforceable agreements governing PRP RI/FS activities;
- Initiation of PRP RI/FS activities and oversight of the RI/FS by EPA;
- EPA control over PRP RI/FS activities; and
- PRP participation in Agency-financed RI/FS activities.

More detailed information regarding each of the above topics is included in Attachments 1-4 of this appendix.

This document is consistent with CERCLA and EPA guidance in effect as of October 1988, and is intended to supersede the March 20, 1984 memorandum from Assistant Administrators Lee M. Thomas and Courtney M. Price entitled "Participation of Potentially Responsible Parties in Development of Remedial Investigations and Feasibility Studies Under CERCLA" (OSWER Directive No. 9835.1). Users of this guidance should consult the RI/FS Guidance or any relevant guidance or policies issued after distribution of this document before establishing EPA/PRP responsibilities for conducting RI/FS activities. Additional guidance regarding procedures for EPA oversight activities will be available in the Office of Waste Program Enforcement's (OWPE) forthcoming "Guidance Manual on Oversight of Potentially Responsible Party Remedial Investigation and Feasibility Studies".

II. Background

Sections 104/122 of CERCLA provide PRPs with the opportunity to conduct the RI/FS when EPA determines (1) that the PRPs are qualified to conduct such activities and (2) they will carry out the activities in accordance with CERCLA requirements and EPA procedures.[1] The Agency will continue its policy of early and timely PRP searches as well as early PRP notification and negotiation for RI/FS activities.

It is also the policy of EPA to encourage the early and active participation of PRPs in conducting RI/FS activities. EPA believes that early participation of PRPs in the remedial process will encourage PRP implementation of the selected remedy. PRP participation in RI/FS activities will ensure that they have a better and more complete understanding of the selected remedy, and thus will be more likely to agree on implementation of the remedy. Remedial activities performed by PRPs will also conserve Fund monies, thus making additional resources available to address other sites.

As part of the Agency's effort to encourage PRP participation in remedial activities, EPA will consider the PRPs' role in conducting RI/FS activities when assessing an overall settlement proposal for the remedial design and remedial action. For example, when the Agency performs a non-binding allocation of responsibility (NBAR), the Agency may consider previous PRP efforts and cooperation. This will provide an additional incentive for PRPs to be cooperative in conducting RI/FS activities.

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* This memorandum was signed by the AA OSWER and released for distribution on May 16, 1988. Technical clarifications/updates have been made to this guidance for insertion into Appendix A of the "Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies" (October 1988-OSWER Directive No. 9355.3-01) (Referred to herein as the RI/FS Guidance).

[1] The legal authority to enter into agreements with PRPs is found in CERCLA Section 122(a). This section then refers to response actions conducted pursuant to Section 104(b). For the purposes of this guidance, Sections 104/122 will be cited when referring to such authority.

Although EPA encourages PRP participation in conducting the RI/FS, the Agency and CERCLA impose certain conditions governing their participation. These conditions are intended to assure that the RI/FS performed by the PRPs is consistent with Federal requirements and that there is adequate oversight of those activities. These conditions are discussed both in Section III and Attachment I of this memorandum.

At the discretion of EPA, a PRP (or group of PRPs) may assume full responsibility for undertaking RI/FS activities pursuant to Sections 104/122 of CERCLA. The terms and conditions governing the RI/FS activities should be specified in an Administrative Order. The use of Administrative Orders is authorized in CERCLA Section 122(d)(3); they are the preferred type of agreement for RI/FS activities since they are authorized internally and therefore, may be negotiated more quickly than Consent Decrees. Before SARA, Administrative Orders were signed using the authorities of Section 106 of CERCLA. New provisions in SARA allow for Orders to be signed using the authorities of Sections 104/122; Section 104/122 Orders do not require EPA to make a finding of imminent and substantial endangerment.

RI/FS activities developed subsequent to the Administrative Order are set forth in a Statement of Work, which is then embodied or incorporated by reference into the Order. A Work Plan describing detailed procedures and criteria by which the RI/FS will be performed is developed by the PRPs and, after approval by EPA, should also be incorporated by reference into the Administrative Order.

It is the responsibility of the lead agency to ensure the quality of the effort if the PRPs assume responsibility for conducting the RI/FS. Therefore, EPA will establish oversight procedures and project controls to ensure that the response actions are consistent with CERCLA and the National Contingency Plan (NCP). Section 104(a)(1) of CERCLA mandates that no PRP be allowed to undertake an RI/FS unless EPA determines that the party(ies) conducting the RI/FS is qualified to do so. In addition, Section 104(a)(1) requires that a qualified party be contracted with or arranged for to assist in overseeing and reviewing the conduct of the RI/FS and, that the PRPs agree to reimburse EPA for the costs associated with the oversight contract or arrangement.

III. Initiation of Enforcement Activities

As part of effective management of enforcement activities, timely settlements for RI/FS activities are to be pursued. This includes conducting PRP searches early in the site discovery process and subsequent notification to all PRPs of their potential liability and of their opportunity to perform response activities. Guidance on conducting timely and effective PRP searches is contained in the guidance manual, "Potentially Responsible Party Search Manual" (August 17, 1987 - OSWER Directive No. 9834.6).

EPA policy has been to notify PRPs of their potential liability for the planned response activities, to exchange information about the site, and to provide PRPs with an opportunity to undertake or finance the response activities themselves. In the past this has been accomplished by issuing a "general notice" letter to the PRPs. In addition to the use of the general notice letter, Section 122(e) of CERCLA now authorizes EPA to use "special notice" procedures, which for an RI/FS, establish a 60 to 90 day moratorium and formal negotiation period. The purpose of the moratorium is to provide time for formal negotiation between EPA and the PRPs for conduct of RI/FS activities. In particular, use of the special notice procedures triggers a 60 day moratorium on EPA conduct of the RI/FS. During the 60 day moratorium, if the PRPs provide EPA with a "good faith offer" to conduct or finance the RI/FS, the negotiation period can be extended to a total of 90 days. EPA considers a good faith offer to be a written proposal where the PRPs make a showing of their qualifications and willingness to conduct or finance the RI/FS. Minor deficiencies in the PRPs' initial submittals should not be grounds for a determination that the offer is not a good faith offer or that the PRPs are unable to perform the RI/FS.

To facilitate, among other things, PRP participation in the RI/FS process, Section 122(e)(1) requires the special notice letter to provide the names and addresses of other PRPs, the volume and nature of substances contributed by each PRP, and a ranking by volume of substances at the site, to the extent this information is available at the time of special notice. Regions are encouraged to release this information to PRPs when the notice letters are issued. To expedite settlements, Regions are also encouraged to give PRPs as much guidance as possible concerning the RI/FS process. It is appropriate to transmit to PRPs copies of important guidance documents such as the RI/FS Guidance, as well as model Administrative Orders and Statements of Work. A model Administrative Order can be found in the memorandum from Gene Lucero entitled, "Model CERCLA Section 106 Consent Order for an RI/FS" (January 31, 1985 - OSWER Directive No. 9835.5). This model order is currently being revised to reflect SARA requirements and will be forthcoming. A model Statement of Work has been included as Appendix C to the RI/FS Guidance, while a model Statement of Work for PRP-lead RI/FSs is currently being developed by OWPE. Other Regional and Headquarters guidance relating to technical issues may be given to PRPs, as well as examples of project plans (plans that must be developed prior to the conduct of the RI/FS) that are of high quality. A description of the required project plans is included in Attachment II.

Although use of the special notice procedures is discretionary, Regions are encouraged to use these procedures in the majority of cases. If EPA decides not to employ the special notice procedures described in Section 122(e), the Agency will notify the PRPs in writing of such a decision, including an explanation as to why EPA believes the use of the special notice procedures is inappropriate. Additional information on the content of special notice letters, including the use of these notice provisions, can be found in the memorandum entitled "Interim Guidance on Notice Letters, Negotiations, and Information Exchange" (October 19, 1987 - OSWER Directive No. 9834.10).

Section 121(f)(1) requires that the State be notified of PRP negotiations and that an opportunity for State participation in such negotiations be provided. In addition, Section 122(j)(1) requires that if a release or threat of release at the site in question may have resulted in damages to natural resources, EPA must notify the appropriate Federal or State Trustee and provide an opportunity for the Trustee to participate in the negotiations. To simplify the notification of Federal Trustees, the Agency intends to provide a list of projects in the Superfund Comprehensive Accomplishments Plan (SCAP) to the Trustees as notice to participate in the negotiations. In those cases where there is reason to believe that a significant natural resource will be affected, direct coordination with the Federal and/or State Trustee will be required.

IV. Conditions for EPA Involvement in, and PRP Initiation of, RI/FS Activities

Under Section 104(a)(1) EPA may authorize PRPs to conduct RI/FS activities at any site, provided the PRPs can do so promptly and properly and can meet the conditions specified by EPA for conducting the RI/FS. These conditions are discussed in Attachment I of this appendix and involve the scope of activities, the organization of the PRPs, and the PRPs' (and their contractors') demonstrated expertise. EPA encourages PRPs to conduct the RI/FS provided that the PRPs commit in an Order (or Consent Decree) under CERCLA Sections 104/122 (or Sections 106/122 for a Decree) to conduct a complete RI/FS to the satisfaction of EPA, under EPA oversight.[2] Oversight of RI/FS activities by the lead agency is required by Section 104(a)(1) and is intended to assure that the RI/FS is adequate for lead agency identification of an appropriate remedy, and that it will otherwise meet the Agency requirements of CERCLA, the NCP, and relevant Agency guidance. EPA will allow PRPs to conduct RI/FS activities and will provide review and oversight under the following general circumstances.

EPA's priority is to address those NPL sites that have been identified on the SCAP. The SCAP is an EPA management plan which identifies site- and activity-specific Superfund financial allocations for each quarter of the current fiscal year. When employing Section 122(e) notice procedures, EPA will notify PRPs of its intention to conduct RI/FS activities at NPL sites in a manner that allows at least 90 days notice before obligating the funds necessary to complete the RI/FS (see Section III of this guidance). During this time frame PRPs may elect to conduct the RI/FS, under the review and oversight of EPA. If the PRPs agree to conduct the RI/FS they must meet the conditions discussed in Attachment I. The scope and terms for conducting the studies are embodied in an Agreement; as mentioned in Section II, Administrative Orders are the preferred type of Agreement for RI/FS activities.

EPA will not engage in lengthy discussions with PRPs over whether the PRPs will conduct the RI/FS; rather, EPA will adhere to the time frames established by the Section 122 special notice provisions. In most instances, once Fund resources have been obligated to conduct the RI/FS, the PRPs will no longer be eligible to conduct the RI/FS activities at the site.

The actions described below are typically taken to initiate RI/FS activities:

- EPA develops a site-specific Statement of Work (SOW) in advance of the scheduled RI/FS start. This SOW is then provided to the PRPs along with a draft of the Administrative Order (or Consent Decree) at the initiation of negotiations. (PRPs may, with EPA approval, submit a single site plan that incorporates the elements of an SOW and a detailed Work Plan as a first deliverable once the Agreement has been signed. This combined site plan must clearly set forth the scope of the proposed RI/FS and would be incorporated into the Agreement in place of the SOW.)
- Final provisions of the SOW are negotiated with the Order.
- EPA determines whether the PRPs possess the necessary capabilities to conduct an RI/FS in a timely and effective manner (conducted simultaneously with other negotiations).
- EPA develops a Community Relations Plan specifying any activities that may be required of

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[2] For a State-lead enforcement site the State is responsible for oversight unless otherwise specified in the agreement between the State and EPA. EPA should maintain communication with the State to ensure that the State is providing oversight of the remedial activities.

the PRPs. (Community relations activities are discussed in Attachment II.)

- EPA determines contractor and staff resources required for oversight and initiates planning the necessary oversight requirements. This process may include preparing a Statement of Work, if a contractor is to develop an "oversight plan."
- EPA and PRPs identify and procure any necessary assistance.
- PRPs submit a Work Plan to EPA for Agency review and approval. The Work Plan must present the methodology and rationale for conducting the RI/FS as well as detailed procedures and requirements, if such procedures have not been set forth in the Agreement. This Work Plan, which in most instances is one of the first deliverables under the Order, is commonly incorporated into the Agreement following EPA approval.
- PRPs are responsible for obtaining access to the site; however, if access cannot be obtained, EPA, with the assistance of DOJ, will secure access subject to PRP reimbursement for the costs incurred in securing such access.

These standardized actions ensure that the scope of the RI/FS activities to be conducted by the PRPs, and the procedures by which the RI/FS is performed, are consistent with EPA policy and guidance. Additional actions may be required either for a technically complex site or for a site where a number of PRPs are involved. Regardless of the circumstances, the actions listed in this section should be negotiated as expeditiously as possible. Specific elements of these actions are discussed in Attachment II.

V. Development of the RI/FS Administrative Order or Consent Decree

The PRPs must respond to EPA's notice letter by either declining, within the time specified, to participate in the RI/FS, or by offering a good faith proposal to EPA for performing the RI/FS. Declining to participate in the RI/FS may be implied if the PRPs do not negotiate during the moratorium established by the notice letter. If the PRPs have declined to participate, or the time specified has lapsed, EPA will obligate funds for performing the RI/FS. If a good faith proposal is submitted, EPA will negotiate with the PRPs on the scope and terms for conducting the RI/FS.

The results of successful negotiations will, in most cases, be contained in an Administrative Order, or where the site is in litigation, in a Judicial Consent Decree entered into pursuant to Section 122(d) of CERCLA. Guidance for the development of an Administrative Order is provided in OWPE's document "Administrative Order: Workshop and Guidance Materials" (September 1984), and in the memorandum from Gene Lucero entitled "Model CERCLA Section 106 Consent Order for an RI/FS" (January 31, 1985). (The latter guidance is currently being revised since the provisions in SARA allow for Orders to be signed using the authorities of Sections 104/122.)

An Administrative Order (or Consent Decree) will generally contain the scope of activities to be performed (either as a Statement of Work or Work Plan), the oversight roles and responsibilities, and enforcement options that may be exercised in the event of noncompliance (such as stipulated penalties). In addition to the above, the Agreement will typically include the following elements, as agreed upon by EPA, the PRPs, and other signatories to the Agreement.

- *Jurisdiction* – Describes EPA's authority to enter into Administrative Orders or Consent Decrees.
- *Parties bound* – Describes to whom the Agreement applies and is binding upon.
- *Purpose* – Describes the purpose of the Agreement in terms of mutual objectives and public benefit.
- *Findings of fact, determination, and conclusions of law* – Provides an outline of facts upon which the Agreement is based, including the fact that PRPs are not subject to a lesser standard of liability and will not receive preferential treatment from the Agency in conducting the RI/FS.
- *Notice to the State* – Verifies that the State has been notified of pending site activities.
- *Work to be performed* – Provides that PRPs submit project plans to the lead-agency for review and approval before commencing RI/FS activities. Project plans are those plans developed in order to effectively conduct the RI/FS project and include: a Work Plan, describing the methodology, rationale, and schedule of all tasks to be performed during the RI/FS; a Sampling and Analysis Plan, describing the field sampling procedures to be performed as well as the quality assurance procedures which will be followed for sampling and analysis (including a description of how the data gathered during the RI/FS will be managed) and the analytical procedures to be employed; and a Health and Safety Plan describing health and safety precautions to be exercised while onsite. (More information on the contents of these project plans can be found in Attachment II of this appendix.)

- *Compliance with CERCLA, the NCP, and Relevant Agency Guidance* – Specifies that the actions at a site will comply with the requirements of CERCLA, the NCP, and relevant Agency guidance determined to be appropriate for site remediation.

- *Reimbursement of costs* – Specifies that PRPs will assume all costs of performing the work required by the Agreement. In addition, this section commits PRPs to reimbursement of costs associated with oversight activities. This includes reimbursement for qualified party assistance in oversight, as required by Section 104(a)(1). This section should also specify the nature and kind of cost documentation to be provided and the process for billing and receiving payment.

- *Reporting* – Specifies the type and frequency of reporting that PRPs must provide to EPA. Normally the reporting requirements will, at a minimum, include the required project plans as well as those deliverables required by the RI/FS Guidance. Additional reporting requirements are left to the discretion of the Regions. That is, Regions may require additional deliverables such as interim reports on particular RI or FS activities.

- *Designated EPA, State, and PRP project coordinators* – Specifies that EPA, the State, and PRPs shall each designate a project coordinator.

- *Site access and data availability* – Stipulates that PRPs shall allow access to the site by EPA, the State, and oversight personnel. Access will be provided for inspection and monitoring purposes that in any way pertain to the work undertaken pursuant to the Order. In addition, access will be provided in the event of project takeover. This section also stipulates that EPA will be provided with all currently available data.

- *Record preservation* – Specifies that all records must be maintained by both parties for a minimum of 6 years after termination of the Agreement, followed by a provision requiring PRPs to offer the site records to EPA before destruction.

- *Administrative record requirements* – Provides that all information upon which the selection of remedy is based must be submitted to EPA in fulfillment of the administrative record requirements pursuant to Section 113 of CERCLA. (Additional information on administrative record requirements is contained in Attachment III.)

- *Dispute resolution* – Specifies steps to be taken if a dispute occurs. The Administrative Order states that with respect to all submittals and work performed, EPA will be the final arbiter, while the court is the final arbiter for a Consent Decree. (More information on dispute resolution can be found in Attachment IV of this appendix.)

- *Delay in performance/stipulated penalties* – Specifies EPA's authority to invoke stipulated penalties for noncompliance with Order or Decree provisions. Section 121 of CERCLA requires that Consent Decrees contain provisions for penalties in an amount not to exceed $25,000 per day. In addition to stipulated penalties, Section 122(l) provides that Section 109 civil penalties apply for violations of Administrative Orders and Consent Decrees. Delays that endanger public health and/or the environment may result in termination of the Agreement and EPA takeover of the RI/FS. (More information on stipulated penalties can be found in the Office of Enforcement and Compliance Monitoring's (OECM) "Guidance on the Use of Stipulated Penalties in Hazardous Waste Consent Decrees" (September 21, 1987) and in Attachment IV of this appendix.)

- *Financial assurance* – Specifies that PRPs should have adequate financial resources or insurance coverage to address liabilities resulting from their RI/FS activities. When using contractors, PRPs should certify that the contractors have adequate insurance coverage or that contractor liabilities are indemnified.

- *Reservation of rights* – States that PRPs are not released from all CERCLA liability through compliance with the Agreement, or completion of the RI/FS. PRPs may be released from liability relating directly to RI/FS requirements, if PRPs complete the RI/FS activities to the satisfaction of EPA.

- *Other claims* – Provides that nothing in the Agreement shall constitute a release from any claim or liability other than, perhaps, for the cost of the RI/FS, if completed to EPA satisfaction. Also provides that nothing in the Agreement shall constitute preauthorization of a claim against the Fund under CERCLA. This section should also specify the conditions for indemnification of the U.S. Government.

- *Subsequent modifications/additional work* – Specifies that the PRPs are committed to perform any additional work or subsequent modifications which are not explicitly stated in the Work Plan, if EPA determines that such work is needed to enable the selection of an appropriate response action. (Attachment IV contains additional information on this clause.)

VI. Statement of Work and Work Plan

Based upon available models and guidance, the Region should present to the PRPs at the initiation of negotiations a Statement of Work (SOW) and draft Administrative Order. The SOW describes the broad objectives and general activities to be undertaken in the RI/FS. (The PRPs may develop the SOW if it is determined to be appropriate for a particular case.) Once the PRPs receive the SOW they develop a more detailed Work Plan, which should be incorporated by reference into the Order following EPA approval. The Work Plan expands the tasks described in the SOW and presents the rationale and methodology (including detailed procedures and schedules) for conducting the RI/FS. It should be noted that EPA, rather than the PRPs, may develop the work plan in the event of unusual circumstances.

VII. Review and Oversight of the RI/FS

To ensure that the RI/FS conforms to the NCP and the requirements of CERCLA, including Sections 104(a)(1) and 121, EPA will review and oversee PRP activities. Oversight is also required to ensure that the RI/FS will result in sufficient information to allow for remedy selection by the lead agency.

The oversight activities that EPA, the State, and other oversight personnel will be performing should be determined prior to the initiation of the RI/FS. Different mechanisms will be used for the review and oversight of different PRP products and activities. These mechanisms, and corresponding PRP activities, should be determined and if possible incorporated in the Order. Generally, the following oversight activities should be specified:

- Review of plans, reports, and records;
- Oversight of field activities (including maintenance of records and documentation);
- Meetings; and
- Special studies.

Section 104(a)(1) requires that the President contract with or arrange for a "qualified person" to assist in the oversight and review of the conduct of the RI/FS. EPA believes that qualified persons, for the purposes of overseeing RI/FS activities, are those firms or individuals with the professional qualifications, expertise, and experience necessary to provide assurance that the Agency is conducting meaningful and effective oversight of PRP activities. In this context, the qualified person generally will be either an ARCs, TES, or REM contractor. EPA employees, employees of other Federal agencies, State employees, or any other qualified person EPA determines to be appropriate however, may be asked to perform the necessary oversight functions.

As part of the Section 104 requirements, PRPs are required to reimburse EPA for qualified party oversight costs. It is Agency policy to recover all response costs at a site including all costs associated with oversight. Additional guidance on oversight and project control activities is presented in Attachments III and IV, respectively.

VIII. Control of Activities

EPA will usually not intervene in a PRP RI/FS if activities are conducted in conformance with the conditions and terms specified by the Order. When deficiencies are detected, EPA will take immediate steps to correct the PRP activities. Deficiencies will be corrected through the use of the following activities: (1) identification of the deficiency; (2) demand for corrective measures; (3) use of dispute resolution mechanisms, where appropriate; (4) imposition of penalties; and if necessary, (5) PRP RI/FS termination and project takeover or judicial enforcement. These activities are described in detail in Attachment IV of this appendix.

IX. PRP Participation in Agency-Financed RI/FS Activities

PRPs that elect not to perform the RI/FS should be allowed an opportunity for involvement in a Fund-financed RI/FS. Private parties may possess technical expertise or knowledge about a site which would be useful in developing a sound RI/FS. Involvement by PRPs in the development of a Fund-financed RI/FS may also expedite remediation by identifying and satisfactorily resolving differences between the Agency and private parties.

Section 113(k)(2)(B) requires that interested persons, including PRPs, be provided an opportunity for participation in the development of the administrative record. PRP participation may include the submittal of information, relevant to the selection of remedy, for inclusion in the record and/or the review of record contents and submittal of comments on such contents.

The extent of additional PRP involvement will be left to the discretion of the Region and may include activities such as:

- Access to the site to observe sampling and analysis activities;
- Access to validated data and draft reports.

With respect to PRP access to a site, it is within the Regions' discretion to impose conditions based on safety and other relevant considerations. To the extent that the Region determines that access is appropriate under the circumstances, PRPs must reimburse EPA for all identifiable costs incurred with the connection of the accesses afforded the PRPs, and must execute appropriate releases in favor of the EPA and its contractors. With respect to providing data, it should be noted that the Region is required to allow private citizens access to the same information that is provided to the PRPs. The Regions must therefore take this into consideration when determining the extent of the PRP's involvement in a Fund-financed RI/FS.

Aside from participation in the administrative record, which is a statutory requirement, the final decision whether to permit PRPs to participate in other aspects of the Fund-financed RI/FS (as well as the scope of any participation) rests with the Regions. This decision should be based on the ability of PRPs to organize themselves so that they can participate as a single entity, and the ability of PRPs to participate without undue interference with or delay in completion of the RI/FS, and other factors that the Regions determine are relevant. The Region may terminate PRP participation in RI/FS development if unnecessary expenses or delays occur.

X. Contact

For further information on the subject matter discussed in this interim guidance, please contact Susan Cange (FTS 475-9805) of the Guidance and Oversight Branch, Office of Waste Program Enforcement.

Attachment I

Conditions for PRP Conduct of the RI/FS

Organization and Management

When several potentially responsible parties are involved at a site they must be able to organize themselves quickly into a single representative body to negotiate with EPA. To facilitate this negotiation process, EPA will make available the names and addresses of other PRPs, in accordance with the settlement provisions of CERCLA Section 122(e). Either a single PRP or an organized group of PRPs may assume responsibility for development of the RI/FS.

Scope of Activities

As part of the negotiation process PRPs must agree to follow the site-specific Statement of Work (SOW) as the basis for conducting an RI/FS. PRPs are required to submit an RI/FS Work Plan setting forth detailed procedures and tasks necessary to accomplish the RI/FS activities described in the SOW. EPA may approve reasonable modifications to the SOW and will reject any requests for modifications that are not consistent with CERCLA (as amended by SARA), the NCP, the requirements set forth in this guidance document, the RI/FS Guidance, or other relevant CERCLA guidance documents.

Demonstrated Capabilities

PRPs must demonstrate to EPA that they possess, or are able to obtain, the technical expertise necessary to perform all relevant activities identified in the SOW, and any amendments that may be reasonably anticipated to that document. In addition, PRPs must demonstrate that they possess the managerial expertise and have developed a management plan sufficient to ensure that the proposed activities will be properly controlled and efficiently implemented. PRPs must also demonstrate that they possess the financial capability to conduct and complete the RI/FS in a timely and effective manner. These capabilities are discussed briefly below.

- Demonstrated Technical Capability

PRPs should be required to demonstrate the technical capabilities of key personnel involved in executing the project. Personnel qualifications may be demonstrated by submitting resumes and references. PRPs may demonstrate the capabilities of the firm that will perform the work by outlining their past areas of business, relevant projects and experience, and overall familiarity with the types of activities to be performed as part of the remedial investigation and feasibility study.

It is important that qualified firms be retained for performing RI/FS activities. Firms that do not have the necessary expertise for performing RI/FS studies may create unnecessary delays in the project and may create situations which further endanger public health or the environment. These situations may be created when PRP contractors submit insufficient project plans, submit deficient reports, or perform inadequate field work. Furthermore, excessive Agency oversight may be required in the event that an unqualified contractor performs the RI/FS; the Agency may have to significantly increase its workload by providing repeated reviews of project plans, reports, and oversight of field activities.

The PRPs must also demonstrate the technical capabilities of the laboratory chosen to do the analysis of samples collected during the RI/FS. If a non-CLP laboratory is selected, EPA may require a submission from the laboratory which provides a comprehensive statement of the laboratories' personnel qualifications, equipment specifications, security measures, and any other material necessary to prove the laboratory is qualified to conduct the work.

- Demonstrated Management Capability

PRPs must demonstrate that they have the administrative capabilities necessary for conducting the RI/FS in a responsible and timely manner. A management plan should be submitted to EPA either during negotiations or as a part of the Work Plan which includes a discussion of roles and responsibilities of key personnel. This management plan should include an RI/FS team organization chart describing responsibilities and lines of authority. Positions and responsibilities should be clearly related to technical and managerial qualifications. The PRPs should also demonstrate an understanding of effective communications, information management, quality assurance, and quality control systems. PRPs usually procure the services of consultants to conduct the required RI/FS activities. The consultants must demonstrate, in addition to those requirements stated above, effective contract management capabilities.

- Demonstrated Financial Capability

The PRPs should develop a comprehensive and reasonable estimate of the total cost of anticipated RI/FS activities. EPA will decide on a case-by-case basis if the PRPs will be required to demonstrate that they have the necessary financial resources available and committed to conduct the RI/FS activities. The resources estimated should be adequate to cover the anticipated costs for the RI/FS as well as the costs for oversight, plus a margin for unexpected expenses. If, during the conduct of the RI/FS the net worth of the financial mechanism providing funding for the RI/FS is reduced to less than that required to complete the remaining activities, the PRPs should mmediately notify EPA. Under conditions specified in the Order, PRPs are required to complete the RI/FS iregardless of initial cost estimates or financial mechanisms.

- Assistance for PRP Activities

If PRPs propose to use consultants for conducting or assisting in the RI/FS, the PRPs should specify the tasks to be conducted by the consultants and submit personnel and corporate qualifications of the proposed firms to the EPA for review. Verification should be made that the PRPs' consultants have no conflict of interest with respect to the project. Any consultants having current EPA assignments as prime contractors or as subcontractors must obtain approval from their EPA Contract Officers before performing work for PRPs. Lack of clarification on possible conflicts of interest may delay the PRP RI/FS. EPA will reserve the right to review the PRPs' proposed selection of consultants and will disapprove their selection if, in EPA's opinion, they either do not possess adequate technical capabilities or there exists a conflict of interest. It should be noted that the responsibility for selection of consultants rests with the PRPs.

Attachment II
Initiation of PRP RI/FS Activities

Development of the Statement of Work

After the PRPs have been identified in the PRP Search Report they are sent either a general notice letter followed by a special notice letter or a general notice letter followed by an explanation pursuant to Section 122(a) why special notice procedures are not being used. EPA will engage in negotiations with those PRPs who have submitted a good faith offer in response to the notice letter and therefore have volunteered to perform the RI/FS. While the PRPs are demonstrating their capabilities for conducting the RI/FS, EPA will negotiate the terms of the Administrative Order. Either an acceptable Statement of Work or Work Plan must be incorporated by reference into the Agreement.

The Statement of Work (SOW) is typically developed by EPA and describes, in a comprehensive manner, all RI/FS activities to be performed, as reasonably anticipated, prior to the onset of the project. The SOW focuses on broad objectives and describes general activities that will be undertaken to achieve these objectives. Detailed procedures by which the work will be accomplished are not presented in the SOW, but are described in the subsequent Work Plan that is developed by the PRPs. In certain instances, with the approval of EPA, PRPs may prepare a single site plan incorporating the elements of an SOW and a Work Plan. In such instances, the site plan will be incorporated into the Order in place of the broader SOW.

- Use of the EPA Model SOW

EPA has developed a model SOW defining a comprehensive RI/FS effort which is contained in the RI/FS Guidance. Additionally, a model SOW for a PRP-lead RI/FS is being developed by OWPE and will be forthcoming. The Regions should develop a site-specific SOW based upon the model(s). RI/FS projects managed by PRPs will involve, at a minimum, all relevant activities set forth in the EPA model SOW. Further, all plans and reports identified as deliverables in the EPA model SOW must be identified as deliverables in the site-specific SOW and/or the Work Plan developed by the PRPs. Additional deliverables may be required by the Regions and should be added to the Administrative Order.

- Modification of the EPA Draft SOW Requirements

The activities set forth in the model SOW are considered by EPA to be the critical RI/FS activities that are required by the NCP. PRPs should present detailed justifications for any proposed modifications and amendments to the activities set forth in the SOW. EPA will review all proposed modifications and approve or disapprove their inclusion in the SOW based on available information, EPA policy and guidance, overall program objectives, and the requirements of the NCP and CERCLA. EPA will not allow modifications that, in the judgment of the Agency, will lead to an unsatisfactory RI/FS or inconsistencies with the NCP.

Review of the RI/FS Project Plans

RI/FS project plans include those plans developed for the RI/FS. At a minimum the project plans should include a Work Plan, a Sampling and Analysis Plan, a Health and Safety Plan, and a Community Relations Plan. The Community Relations Plan is developed by EPA and should include a description of the PRPs' role in community relations activities, if any. EPA review and approval of the work plan and sampling and analysis plan will usually be required before PRPs can begin site activities. An example when limited project activities may be initiated prior to approval of the project plans would be if additional information is required to complete the Sampling and Analysis Plan. Additionally, conditional approvals to the Work Plan and Sampling and Analysis Plan may be provided in order to initiate field activities in a more timely manner. It should be noted that EPA does not "approve" the PRPs' Health and Safety Plan but rather, it is reviewed to ensure the protection of public health and the environment. The PRPs may be required to amend the plan if EPA determines that it does not adequately provide for such protection.

- Contents of the Work Plan

The Work Plan expands the tasks of the SOW, and the responsibilities specified in the Agreement, by presenting the rationale and methodology (including detailed procedures) for conducting the RI/FS. Typically the Work Plan is developed after the draft Order and then incorporated into the Agreement. In some cases however, it may be appropriate for EPA to develop the Work Plan prior to actual negotiation with the PRPs and attach the plan to the draft Agreement. The PRP RI/FS Work Plan must be consistent with current EPA guidance. Guidance on developing acceptable Work Plans is available in the RI/FS Guidance. Additional guidance will be forthcoming in the proposed NCP. Once the Work Plan is approved by EPA, it becomes a public document and by the terms of the Agreement, should be incorporated by reference into that document. The Work Plan should, at a minimum, contain the following elements.

Introduction/Background Statement – PRPs should provide an introductory or background statement describing their understanding of the work to be performed at the site. This should include historical site information and should highlight present site conditions.

Objectives – A statement of what is to be accomplished and how the information will be utilized.

Scope – A detailed description of the work to be performed including a definition of work limits.

Management Plan – A description of the project management showing personnel with authority and responsibility for the appropriate aspects of the project and specific tasks to be performed. A single person should be identified as having overall responsibility for the project.

Work Schedule – A statement outlining the schedule for each of the required activities. This could be presented in the form of a Gantt or milestone chart. The schedule in the Work Plan must match that in the draft Order.

Deliverables – A description of the work products that will be submitted and their schedule for delivery. The schedule should include specific dates, if possible. Otherwise, the schedule should be in terms of the number of days/week after approval of the work plan.

- Contents of the Sampling and Analysis Plan.

A Sampling and Analysis Plan (SAP) must be submitted by the PRPs before initiation of relevant field activities. This plan contains two separate elements: a Field Sampling Plan and a Quality Assurance Project Plan. These documents were previously submitted as separate deliverables, but are now combined into one document. Though the SAP s typically implemented by PRP contractors, it is the responsibility of the PRPs to ensure that the goals and standards of the plan are met. (Verification that the goals and standards of the SAP are met will also be part of EPA's oversight responsibilities.) The SAP should contain the following elements:

Field Sampling Plan – The Field Sampling Plan includes a detailed description of all RI/FS sampling and analytical activities that will be performed. These activities should be consistent with the NCP and relevant CERCLA guidance. Further guidance on developing Field Sampling Plans is presented in the RI/FS Guidance.

Quality Assurance Project Plan – The SAP must include a detailed description of quality assurance/quality control (QA/QC) procedures to be employed during the RI/FS. This section is intended to ensure that the RI/FS is based on the correct level or extent of sampling and analysis required to produce sufficient data for evaluating remedial alternatives for a specific site. A second objective is to ensure the quality of the data collected during the RI/FS. Guidance on appropriate QA/QC procedures may be found in the RI/FS Guidance as well as "Data Quality Objectives for the RI/FS Process" (March 1987 – OSWER Directive No. 9355.0–7B).

If the SAP modifies any procedures established in relevant guidance, it must provide an explanation and justification for the change.

- Other Project Plans

Other project plans that are likely to be required in the RI/FS process include the Health and Safety Plan and the Community Relations Plan.

Health and Safety Plan – PRPs should include a Health and Safety Plan either as part of the Work Plan or as a separate document. The Health and Safety Plan should address the measures taken by the PRPs to ensure that all activities will be conducted in an environmentally safe manner for the workers and the surrounding community. EPA reviews the Health and Safety Plan to ensure protection of public health and the environment. EPA does not, however, "approve" this plan. Guidance on the appropriate contents of a Health and Safety Plan may be found in the RI/FS Guidance. In addition, Health and Safety requirements are found in "OSHA Safety and Health Standards: Hazardous Waste Operations and Emergency Response" (40 CFR Part 1910.120).

Community Relations Plan – EPA must prepare a Community Relations Plan for each NPL site. The extent of PRP involvement in community relations activities should be detailed in this plan. Additional information on Community Relations activities is contained below.

- Review and Approval

PRPs must submit all of the required RI/FS project plans (with the exception of the Community Relations Plan which is developed by EPA) to EPA for review, and in the case of the Work Plan and SAP, approval. EPA will review the plans for their technical validity and consistency with the NCP and relevant EPA guidance. Typically, the Agency must review and approve these plans before PRPs can begin any site activities. Any disagreements that arise between EPA and PRPs over the contents of the plans should be resolved according to the procedures set forth in the dispute resolution section of the relevant EPA/PRP Agreement.

Community Relations

EPA is responsible for developing and implementing an effective community relations program, regardless of whether RI/FS activities are Fund-financed or conducted by PRPs. At State-lead enforcement sites, funded by EPA under Superfund Memoranda of Agreement (see the "Draft Guidance on Preparation of a Superfund Memorandum of Agreement (October 5, 1987 – OSWER Directive No. 9375.0-01)), the State has the responsibility for development and implementation of a community relations program. PRPs may, under certain circumstances, assist EPA or the State in implementing the community relations activities. For example, PRPs may wish to participate in community meetings and in preparing fact sheets. PRP participation in community relations activities would, however, be at the discretion of the Regional Office, or the State, and would require oversight by the lead-agency. EPA will not under any circumstances negotiate press releases with PRPs.

EPA designs and implements community relations activities according to CERCLA and the NCP. A Community Relations Plan must be developed by EPA for all NPL sites as described by the EPA guidance, "Community Relations in Superfund: A Handbook" (U.S. EPA, 1988 – OSWER Directive No. 9230.0-03). The Community Relations Plan must be independent of negotiations with PRPs. Guidance for conducting community relations activities at Superfund enforcement sites is specifically addressed by Chapter VI of the Handbook and the EPA memo entitled "Community Relations Activities at Superfund Enforcement Sites--Interim Guidance" (November 1988 - OSWER Directive No. 9230.0-3B). In some instances the decision regarding PRP participation in community relations activities will be made after the Community Relations Plan has been developed. As a result, the plan will need to be modified by EPA to reflect Agency and PRP roles and responsibilities. EPA, or the State, will provide the Community Relations Plan to all interested parties at the same time. In general, if the case has not been referred to the Department of Justice (DOJ) for litigation, community relations activities during the RI/FS should be the same for Fund- and PRP-lead sites. If the case has been (or may potentially be) referred to DOJ for litigation, constraints will probably be placed on the scope of activities. The EPA Community Relations Plan may be modified after consultation with the technical enforcement staff, the Regional Counsel and other negotiation team members, including, if the case is referred, the lead DOJ or Assistant United States Attorneys (i.e., the litigation team). This technical and legal staff must be consulted prior to any public meetings or dissemination of fact sheets or other information; approval must be obtained prior to releases of information and discussions of technical information in advance. PRP participation in implementing community relations activities will be subject to EPA (or State) approval in administrative settlements and EPA/DOJ in civil actions. Key activities specific to community relations programs for enforcement sites include the following:

- Public Review of Work Plans for Administrative Orders

The PRP Work Plan, as approved by EPA, is incorporated into the Administrative Order (or Consent Decree). Once the Agreement is signed, it becomes a public document. Although there is no requirement for public comment on an Administrative Order, Regional staff are encouraged to announce, after the Order is final, that the PRP is conducting the RI/FS. Publication of notice and a corresponding 30-day comment period is required however, for Consent Decrees.

- Availability of RI/FS Information from the PRPs

PRPs, in agreeing to conduct the RI/FS, must also agree to provide all information necessary for EPA to implement a Community Relations Plan. The Agreement should identify the types of information that PRPs will provide, and contain conditions concerning the provision of this information. EPA should provide the PRPs with the content of the plan so that the PRPs can fully anticipate the type of information that will be made public. All information submitted by PRPs will be subject to public inspection (i.e., available through Freedom of Information Act requests, public dockets, or the administrative record) unless the information meets an exemption. An example would be if the information is deemed either as enforcement sensitive by EPA, or business confidential by EPA (based on the PRPs' representations), in conformance with 40 CFR Part 2.

Development of the ATSDR Health Assessment

Section 104(j)(6) of CERCLA requires the Agency for Toxic Substances and Disease Registry (ATSDR) to perform health assessments at all NPL facilities according to a specified schedule. The purpose of the health assessment is to assist in determining whether any current or potential threat to human health exists and to determine whether additional information on human exposure and associated health risks is needed.

The EPA remedial project manager (RPM) should coordinate with the appropriate ATSDR Regional representative for initiation of the health assessment. In general, the health assessment should be initiated at the start of the RI/FS. The ATSDR Regional representative will provide information on data needs specific to performing a health assessment to ensure that all necessary data will be collected during the RI. The RPM and the ATSDR Regional representative should also coordinate the transmission and review of pertinent documents dealing with the extent and nature of site contamination (i.e., applicable technical memoranda and the draft RI). As ATSDR has no provisions for withholding documents, if requested by the public, the RPM must discuss enforcement sensitive documents and drafts with the ATSDR Regional representative rather than providing copies to them. This will ensure EPA's enforcement confidentiality. Further guidance on coordination of RI/FS activities with ATSDR can be found in the document entitled "Guidance for Coordinating ATSDR Health Assessment Activities with the Superfund Remedial Process" (March 1987 - OSWER Directive No. 9285.4-02).

Identification of Oversight Activities

EPA will review RI/FS plans and reports as well as provide field oversight of PRP activities during the RI/FS. To ensure that adequate resources are committed and that appropriate activities are performed, EPA should develop an oversight plan that defines the oversight activities that must be performed including EPA responsibilities, RI/FS products to be reviewed, and site activities that EPA will oversee. In planning for oversight, EPA should consider such factors as who will be performing oversight and the schedule of activities that will be monitored. A tracking system for recording PRP milestones should be developed. This system should also track activities performed by oversight personnel and other appropriate cost items such as travel expenses.

Identification and Procurement of EPA Assistance

In accordance with Section 104(a)(1) EPA must arrange for a qualified party to assist in oversight of the RI/FS. The following section provides guidance for identifying and procuring such assistance for EPA activities.

- Assistance for EPA Activities

As specified in Section 104(a)(1), EPA is required to contract with or arrange for a qualified person to assist in oversight of the RI/FS. Qualified individuals are those groups with the professional qualifications, expertise, and experience necessary to provide assurance that the Agency is conducting appropriate oversight of PRP RI/FS activities.

Normally, EPA will obtain oversight assistance either through the Technical Enforcement Support (TES) contract, the Alternative Remedial Contracts Strategy Contract (ARCS), or occasionally through the Remedial Action (REM) contracts. In some cases oversight assistance may be provided by States through the use of Cooperative Agreements. Oversight assistance may also be obtained through the U.S. Army Corps of Engineers or other governmental agencies; interagency Agreements should be utilized to obtain such assistance.

Attachment III

Review and Oversight of the RI/FS

Review of Plans, Reports, and Records

EPA will review all RI/FS products which are submitted to the Agency as specified in the Work Plan or Administrative Order. PRPs should ensure that all plans, reports, and records are comprehensive, accurate, and consistent in content and format with the NCP and relevant EPA guidance. After this review process, EPA will either approve or disapprove the product. If the product is found to be unsatisfactory, EPA will notify the PRPs of the discrepancies or deficiencies and will require corrections within a specified time period.

- Project Plans

EPA will review all project plans that are submitted as deliverables in fulfillment of the Agreement. These plans include the Work Plan, the Sampling and Analysis Plan (including both the Field Sampling Plan and the Quality Assurance Project Plan), and the Health and Safety Plan. If the initial submittals are not sufficient in content or scope, the RPM will request that the PRPs submit revised document(s) for review. EPA does not "approve" the PRP's Health and Safety Plan but rather, it is reviewed to ensure the protection of public health and the environment. The PRP's Work Plan and Sampling and Analysis Plan, on the other hand, must be reviewed and approved prior to the initiation of field activities. Conditional approval to these plans may be provided in order to initiate field activities in a more timely manner.

The PRPs may be required to develop additional Work Plans or modify the initial Work Plan contained in or created pursuant to the Agreement. These changes may result from the need to: (1) re-evaluate the RI/FS activities due either to changes in or unexpected site conditions; (2) expand the initial Work Plan when additional detail is necessary; or (3) modify or add products to the Work Plan based on new information (e.g., a new population at risk). EPA will review and approve all Work Plans and/or modifications to Work Plans once they are submitted for review.

- Reports

PRPs will, at a minimum, submit monthly progress reports, technical memorandums or reports, and the draft and final RI/FS reports as required in the Agreement. To assist in the development of the RI/FS and review of documents, additional deliverables may be specified by the Region and included in the Agreement. These reports and deliverables will be reviewed by EPA to ensure that the activities specified in the Order and approved Work Plan are being properly implemented. These reports will generally be submitted according to the conditions and schedule set forth in the Agreement. Elements of the PRP reports are discussed below.

Monthly Progress Reports – The review of monthly progress reports is an important activity performed during oversight. These reports should provide sufficient detail to allow EPA to evaluate the past and projected progress of the RI/FS. PRPs should submit these written progress reports to the RPM. The report should describe the actions and decisions taken during the previous month and activities scheduled during the upcoming reporting period. In addition, technical data generated during the month (i.e., analytical results) should be appended to the report. Progress reports should also include a detailed statement of the manner and extent to which the procedures and dates set forth in the Agreement/Work Plan are being met. Generally, EPA will determine the adequacy of the performance of the RI/FS by reviewing the following subjects discussed in progress reports:

- Technical Summary of Work

  The monthly report will describe the activities and accomplishments performed to date. This will generally include a description of all field work completed, such as sampling events and installation of wells; a discussion of analytical results received; a discussion of data review activities; and a discussion of the development, screening, and detailed analysis of alternatives. The report will also describe the activities to be performed during the upcoming month.

- Schedule

EPA will oversee PRP compliance with respect to those schedules specified in the Order. Delays, with the exception of those specified under the Force Majeure clause of the Agreement, may result in penalties, if warranted. The RPM should be immediately notified if PRPs cannot perform required activities or cannot provide the required deliverables in accordance with the schedule specified in the Work Plan. In addition, PRPs should notify the RPM when circumstances may delay the completion of any phase of the work or when circumstances may delay access to the site. PRPs should also provide to the RPM, in writing, the reasons for, and the anticipated duration of, such delays. Any measures taken or to be taken by the PRPs to prevent or minimize the delay should be described including the timetables for implementing such measures.

- Budget

The relationship of budgets to expenditures should be tracked where the RI/FS is funded with a financial mechanism established by the PRPs. If site activities require more funds than originally estimated, EPA must be assured that the PRPs are financially able to undertake additional expenditures. While EPA does not have the authority to review or approve a PRP budget, evaluating costs during the course of the RI/FS allows EPA to effectively monitor activity to ensure timely completion of RI/FS activities. If the PRPs run over budget, EPA must be assured that they can continue the RI/FS activities as scheduled. Therefore, if specified in the Agreement, PRPs should submit budget expenditures and cost overrun information to EPA. Budget reports need not present dollar amounts, but should indicate the relationship between remaining available funds and the estimate of the costs of remaining activities.

- Problems

Any problems that the PRPs encounter which could affect the satisfactory performance of the RI/FS should be brought to the immediate attention of EPA. Such problems may or may not be a force majeure event, or caused by a force majeure event. EPA will review problems and advise the PRPs accordingly. Problems which may arise include, but are not limited to:

- Delays in mobilization or access to necessary equipment;
- Unanticipated laboratory/analytical time requirements;
- Unsatisfactory QA/QC performance;
- Requirements for additional or more complex sampling;
- Prolonged unsatisfactory weather conditions;
- Unanticipated site conditions; and
- Unexpected, complex community relations activities.

Other Reports - All other reports, such as technical reports and draft and final RI/FS reports, should be submitted to EPA according to the schedule contained in the Order or the approved Work Plan. EPA will review and approve these reports as they are submitted. Suggested formats for the RI/FS reports are presented in the RI/FS Guidance.

- Records

PRPs should preserve all records, documents, and information of any kind relating to the performance of work at the site for a minimum of 6 years after completion of the work and termination of the Administrative Order. After the 6-year period, the PRPs should offer the records to EPA before their destruction.

Document control should be a key element of all recordkeeping. The following activities require careful recordkeeping and will be subject to EPA oversight:

Administration – PRP administrative activities should be accurately documented and recorded. Necessary precautions to prevent errors or the loss or misinterpretation of data should be taken. At a minimum, the following administrative actions should be documented and recorded:

- Contractor work plans, contracts, and change orders;
- Personnel changes;
- Communications between and among PRPs, the State, and EPA officials regarding technical aspects of the RI/FS;
- Permit application and award (if applicable); and
- Cost overruns.

Technical Analysis – Samples and data should be handled according to procedures set forth in the Sampling and Analysis Plan. Documentation establishing adherence to these procedures should include:

- Sample labels;
- Shipping forms;
- Chain-of-custody forms; and
- Field log books.

All analytical data in the RI/FS process should be managed as set forth in the Sampling and Analysis Plan. Such analytical data may be the product of:

- Contractor laboratories;
- Environmental and public health studies; and
- Reliability, performance, and implementability studies of remedial alternatives.

Decision Making – Actions or communications among PRPs that involve decisions affecting technical aspects of the RI/FS should be documented. Such actions and communications include those of the project manager (or other PRP management entity), steering committees, or contractors.

- Administrative Record Requirements

Section 113(k) of CERCLA requires that the Agency establish an administrative record upon which the selection of a response action is based. A suggested list of documents which are most likely to be included in any adequate administrative record is provided in the memorandum entitled "Draft Interim Guidance on Administrative Records for Selection of CERCLA Response Actions" (June 23, 1988 – OSWER Directive No. 9833.3A). More detailed guidance will be forthcoming, including guidance provided in the revisions to the NCP. There are, however, certain details associated with compiling and maintaining an administrative record that are unique to PRP RI/FS activities.

EPA is responsible for compiling and maintaining the administrative record, and generating and updating an index. If EPA and the PRPs mutually agree, the PRPs may be allowed to house and maintain the administrative record file at or near the site; they may not, however, be responsible for the actual compilation of the record. Housing and maintaining the administrative record would include setting up a publicly accessible area at or near the site and ensuring that documents remain and are updated as necessary. EPA must always be responsible for deciding whether documents are included in the administrative record; transmitting records to the PRPs; and maintaining the index to the repository.

The information which may comprise the administrative record must be available to the public from the time an RI/FS Work Plan is approved by EPA. Once the Work Plan has been approved the PRPs must transmit to EPA, at reasonable, regular intervals, all of the information that is generated during the RI/FS that is related to selection of the remedy. The required documentation should be specified in the Administrative Order. The Agreement should also specify those documents generated prior to the RI/FS that must be obtained from the PRPs for inclusion in the record file. This may include any previous studies conducted under State or local authorities, management documents held by the PRPs such as hazardous waste shipping manifests, and other information about site characteristics or conditions not contained in any of the above documents.

Field Activities

- Field Inspections

Field inspections are an important oversight mechanism for determining the adequacy of the work performed. EPA will therefore conduct field inspections as part of its oversight responsibilities. The oversight inspections should be performed in a way that minimizes interference with PRP site activities or undue complication of field activities. EPA will take corrective steps, as described in Section VII and Attachment IV of this appendix, if unsatisfactory performance or other deficiencies are identified.

Several field-related tasks may be performed during oversight inspections. These tasks include:

On-site presence/inspection – As specified in Section 104(e)(3), EPA reserves the right to conduct on-site inspections at any reasonable time. EPA will therefore establish an on-site presence to assure itself of the quality of work being conducted by PRPs. At a minimum, field oversight will be conducted during critical times, such as the installation of monitoring wells and during sampling events. EPA will focus on whether the PRPs adhere to procedures specified in the SOW and Work Plan(s), especially those concerning QA/QC procedures. Further guidance regarding site characterization activities is presented in the RI/FS Guidance, the "Compendium of Superfund Field Operations Methods" (August 1987 – OSWER Directive No. 9355.0-141), the "RCRA Ground Water Technical Enforcement Guidance Document" (September 1986 – OSWER Directive No. 9950.1), the NEIC Manual for *Groundwater/Subsurface Investigations at Hazardous Waste*

Sites (U.S. EPA, 1981c), and OWPE's forthcoming "Guidance on Oversight of Potentially Responsible Party Remedial Investigations and Feasibility Studies."

Collection and analysis of samples – EPA may collect a number of QA/QC samples including blank, duplicate, and split samples. The results of these sample analyses will be compared to the results of PRP analyses. This comparison will enable EPA to identify potential quality control problems and therefore help to evaluate the quality of the PRP investigation.

Environmental Monitoring – EPA may supplement any PRP environmental monitoring activity. Such supplemental monitoring may include air or water studies to determine additional migration of sudden releases that may have occurred as a result of site activities.

- QA/QC Audits

EPA may either conduct, or require the PRPs to conduct (if specified in the Agreement), laboratory audits to ensure compliance with proper QA/QC and analytical procedures, as specified in the Sampling and Analysis Plan. These audits will involve on-site inspections of laboratories used by PRPs and analyses of selected QA/QC samples. All procedures must be in accordance with those outlined in *The User's Guide to the Contract Laboratory Program*, (U.S. EPA, 1986) or otherwise specified in the Sampling and Analysis Plan.

- Chain-of-Custody

Chain-of-custody procedures will be evaluated by EPA. This evaluation will focus on determining if the PRPs and their contractors adhere to the procedures set forth in the Sampling and Analysis Plan. Proper chain-of-custody procedures are described in the *National Enforcement Investigation Center (NEIC) Policies and Procedures Manual*, (U.S. EPA, 1981b). Evaluation of chain-of-custody procedures will occur during laboratory audits as well as during on-site inspections of sampling activities.

Meetings

Meetings between EPA, the State, and PRPs should be held on a regular basis (as specified in the Agreement) and at critical times during the RI/FS. Such critical times may at a minimum include when the SOW and the Work Plan are reviewed, the RI is in progress and completed, remedial alternatives are developed and screened, detailed analysis of the alternatives is performed, and the draft and final RI/FS reports are submitted. These meetings will discuss overall progress, discrepancies in the work performed, problems encountered in the performance of RI/FS activities and their resolution, community relations, and other related issues and concerns. While meetings may be initiated by either the PRPs or EPA at any time, they will generally be conducted at the stages of the RI/FS listed below.

- Initiation of Activities

EPA, the State, and the PRPs may meet at various times before field activities begin to discuss the initial planning of the RI/FS. Meetings may be arranged to discuss, review, and approve the SOW; to develop the EPA/PRP Agreement; and to develop, review, and approve the Work Plan.

- Progress

EPA may request meetings to discuss the progress of the RI/FS. These meetings should be held at least quarterly and will focus on the items submitted in the monthly progress reports and the findings from EPA oversight activities. Any problems or deficiencies in the work will be identified and corrective measures will be requested (see Section VIII and Attachment IV of this appendix).

- Closeout

EPA may request a closeout meeting upon completion of the RI/FS. This meeting will focus on the review and approval of the final RI/FS report, termination of the RI/FS Agreement, and any final on-site activities which the PRPs may be required to perform. These activities may include maintaining the site and ensuring that fences and warning signs are properly installed. The transition to remedial design and remedial action will also be discussed during this meeting.

Special Studies

EPA may determine that special studies related to the PRP RI/FS are required. These studies can be conducted to verify the progress and results of RI/FS activities or to address a specific complex or controversial issue. Normally, special studies are performed by the PRPs; however, there may be cases in which EPA will want to conduct the independent studies. The PRPs should be informed of any such studies and given adequate time to provide necessary coordination of site personnel and resources. If not provided for in the Agreement, modifications to the Work Plan may be required.

Attachment IV

Control of Activities

Identification of Deficiencies

Oversight activities may identify unsatisfactory or deficient PRP performance. The determination of such performance may be based upon findings such as:

- Work products are inconsistent with the SOW or Work Plan;
- Technical deficiencies exist in submittals or other RI/FS products;
- Unreasonable delays occur while performing RI/FS activities; and
- Procedures are inconsistent with the NCP.

Corrective Measures

The need to perform corrective measures may arise in the event of deficiencies in reports or other work products, or unsatisfactory performance of field or laboratory activities. When deficiencies are identified corrective measures may be sought by: (1) notifying the PRPs; (2) describing the nature of the deficiency; and (3) either requesting the PRPs to take whatever actions they regard as appropriate or setting forth appropriate corrective measures. The following subsections describe this process for each of the two general types of activities that may require corrective measures.

- Corrective Measures Regarding Work Products

Agency review and approval procedures for work products generally allow three types of responses: (1) approval; (2) approval with modifications; and (3) non-approval. Non-approval of a work product (including project plans) immediately constitutes a notice of deficiency. EPA will immediately notify the PRPs if any work product is not approved and will explain the reason for such a finding.

Approval with modifications will not lead to a notice of deficiency if the modifications are made by the PRPs without delay. If the PRPs significantly delay in responding to the modifications, the RPM would issue a notice of deficiency to the PRP project manager detailing the following elements:

- A description of the deficiency or a statement describing in what manner the work product was found to be deficient or unsatisfactory;
- Modifications that the PRPs should make in the work product to obtain approval;
- A request that the PRPs prepare a plan, if necessary, or otherwise identify actions that will lead to an acceptable work product;
- A schedule for submission of the corrected work product;
- An invitation to the PRPs to discuss the matter in a conference; and
- A statement of the possibility of EPA takeover at the PRPs' expense, EPA enforcement, or penalties (as appropriate).

- Corrective Measures Regarding Field Activities

When the lead agency discovers that the PRPs (or their contractors) are performing the RI/FS field work in a manner that is inconsistent with the Work Plan, the PRPs should be notified of the finding and asked to voluntarily take appropriate corrective measures. The request is generally made at a progress meeting, or, if immediate action is required, at a special meeting held specifically to discuss the problem. If corrective measures are not voluntarily taken, the RPM should, in conjunction with appropriate Regional Counsel, issue a notice of deficiency containing the following elements:

- A description of the deficiency;
- A request for an explanation of the failure to perform satisfactorily and a plan for addressing the necessary corrective measures;

- A statement that failure to present an explanation may be taken as an admission that there is no valid explanation;
- An invitation to discuss the matter in a conference (where appropriate);
- A statement that stipulates penalties may accrue or are accruing, project termination may occur, and/or civil action may be initiated if appropriate actions are not taken to correct the deficiency; and
- A description of the potential liabilities incurred in the event that appropriate actions are not taken.

Modifications to the Work Plan/Additional Work

Under the Administrative Order (or Consent Decree), PRPs agree to complete the RI/FS, including the tasks required under either the original Work Plan or a subsequent or modified Work Plan. This may include determinations and evaluations of conditions that are unknown at the time of execution of the Agreement. Modifications to the original RI/FS Work Plan are frequently required as field work progresses. Work not explicitly covered in the Work Plan is often required and therefore provided for in the Order. This work is usually identified during the RI and is driven by the need for further information in a specific area. In general, the Agreement should provide for fine-tuning of the RI, or the investigation of an area previously unidentified. As it becomes clear what additional work is necessary, EPA will notify the PRPs of the work to be performed and determine a schedule for completion of the work.

EPA must ensure that clauses for modifications to the Work Plan are included in the Agreement so that the PRPs will carry out the modifications as the need for them is identified. To facilitate negotiation on these points, EPA may consider one or more of the following provisions in the Agreement for addressing such situations:

- Defining the limits of additional work requirements;
- Specifying the dispute resolution process for modified Work Plans and additional work requirements;
- Defining the applicability of stipulated penalties to any additional work which the PRPs agree to undertake.

Dispute Resolution

As discussed elsewhere in this guidance, the RI/FS Order developed between EPA and the PRPs sets forth the terms and conditions for conducting the RI/FS. An element of this Agreement is a statement of the specific steps to be taken if a dispute arises between EPA (or its representatives) and the PRPs. These steps should be well defined and agreed upon by all signatories to the Agreement.

A dispute with respect to the Order is followed by a specific period of discussion with the PRPs. After the discussion period, EPA issues a final decision which becomes incorporated into the Agreement. Administrative Orders should clarify that with respect to all submittals and work performed, EPA will be the final arbiter. The court, on the other hand, is the final arbiter for Consent Decrees.

Penalties

As an incentive for PRPs to properly conduct the RI/FS and correct any deficiencies discovered during the conduct of the Agreement, EPA should include stipulated penalties. Section 121 provides up to $25,000 per day in stipulated penalties for violations of a Consent Decree while Section 122 allows EPA to seek or impose civil penalties for violations of Administrative Orders.[3] Penalties should begin to accrue on the first day of the deficiency and continue to be assessed until the deficiency is corrected. The type of violation (i.e., reporting requirements vs. implementation of construction requirements), as well as the amounts, should be specified as stipulated penalties in the Agreement to avoid negotiations on this point which may delay the correction. The amounts should be set pursuant to the criteria of Section 109 and as such must take into account the nature, circumstances, extent, and gravity of the violations as well as the PRPs' ability to pay, prior history of violations, degree of culpability, and the economic benefit resulting from noncompliance. Additional information on stipulated penalties can be found in OECM's "Guidance on the Use of Stipulated Penalties in Hazardous Waste Consent Decrees" (September 27, 1987).

Project Takeover

Generally, EPA will consult with PRPs to discuss deficiencies and corrective measures. If these discussions fail, EPA has two options: (1) pursue legal action to force the PRPs to continue the work; or (2) take over the RI/FS. If taking legal action will not significantly delay implementation of necessary remedial or removal actions, EPA may commence civil action against the noncomplying PRP to enforce the Administrative Order. Under a Consent Decree, the matter would be presented to the court in which the Decree was filed to enforce the provisions of the Decree.

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[3] In order to provide for stipulated penalties in an Administrative Order the parties must voluntarily include them in the terms of the Agreement.

If a delay in RI/FS activities endangers public health and/or the environment or will significantly delay implementation of necessary remedial actions, EPA should move to replace the PRP activities with Fund-financed actions. The RPM will take the appropriate steps to assume responsibility for the RI/FS, including issuing a stop-work order to the PRPs and notifying the EPA remedial contractors. In issuing stop work orders, RPMs should be aware that Fund resources may not be automatically available. But, in the case of PRP actions which threaten human health or the environment, there may be no other course of action. Once this stop work order is issued, a fund-financed RI/FS will be undertaken consistent with EPA funding procedures.

Appendix B

Elements of RI/FS Project Plans

I. Elements of a Work Plan[1]

Introduction – A general explanation of the reasons for the RI/FS and the expected results or goals of the RI/FS process are presented.

Site Background and Physical Setting – The current understanding of the physical setting of the site, the site history, and the existing information on the condition of the site are described. (See Section 2.2.2.1.)

Initial Evaluation – The conceptual site model developed during scoping is presented, describing the potential migration and exposure pathways and the preliminary assessment of human health and environmental impacts. (See Section 2.2.2.2).

Work Plan Rationale – Data requirements for both the risk assessment and the alternatives evaluation identified during the formulation of the DQOs are documented, and the work plan approach is presented to illustrate how the activities will satisfy data needs.

RI/FS Tasks – The tasks to be performed during the RI/FS are presented. This description incorporates RI site characterization tasks identified in the QAPP and the FSP, the data evaluation methods identified during scoping (see Section 2.2.9), and the preliminary determination of tasks to be conducted after site characterization (see Section 2.2.7 of this guidance).

II. Standard Federal-Lead RI/FS Work Plan Tasks

Task 1. Project Planning (Project Scoping)

This task includes efforts related to initiating a project after the SOW is issued. The project planning task is defined as complete when the work plan and supplemental plans are approved (in whole or in part). The following typical elements are included in this task:

- Work plan memorandum
- Kickoff meeting (RI/FS brainstorming meeting)
- Site visit/meeting
- Obtaining easements/permits/site access
- Site reconnaissance and limited field investigation
- Site survey[2]/topographic map/review of existing aerial photographs
- Collection and evaluation of existing data
- Development of conceptual site model
- Identification of data needs and DQOs
- Identification of preliminary remedial action objectives and potential remedial alternatives
- Identification of treatability studies that may be necessary
- Preliminary identification of ARARs
- Preparation of plans (e.g., work plan, health and safety plan, QAPP, FSP)
- Initiation of subcontract procurement
- Initiation of coordination with analytical laboratories (CLP and non-CLP)
- Task management and quality control

Task 2. Community Relations

This task incorporates all efforts related to the preparation and implementation of the community relations plan for the site and is initiated during the scoping process. It includes time expended by both technical and community relations personnel. This task ends when community relations work under Task

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[1] These elements are required in a work plan but do not necessarily represent the organization of a work plan.

[2] A site survey may be conducted during project planning or may occur during the field investigation task but should not occur in both.

12 is completed, but the task does not include work on the responsiveness summary in the ROD (see Task 12). The following are typical elements included in this task:

- Conducting community interviews
- Preparing a community relations plan
- Preparing fact sheets
- Providing public meeting support
- Providing technical support for community relations
- Implementing community relations
- Managing tasks and conducting quality control

Task 3. Field Investigation

This task involves efforts related to fieldwork in conducting the RI. It includes the procurement of subcontractors related to field efforts. The task begins when any element, as outlined in the work plan, is approved (in whole or in part) and fieldwork is authorized.[3] Field investigation is defined as complete when the contractor and subcontractors are demobilized from the field. The following activities are typically included in this task.

- Procurement of subcontracts
- Mobilization
- Media sampling
- Source testing
- Geology/hydrogeological investigations
- Geophysics
- Site survey/topographic mapping (if not performed in project planning task)
- Field screening/analyses
- Procurement of subcontractors
- RI waste disposal
- Task management and quality control

Task 4. Sample Analysis/Validation

This task includes efforts relating to the analysis and validation of samples after they leave the field. Separate monitoring of close support laboratories may be required. Any efforts associated with laboratory procurement are also included in this task. The task ends on the date that data validation is complete. The following typical activities are usually included in this task:

- Sample management
- Non-CLP analyses
- Use of mobile laboratories
- Data validation
- Testing of physical parameters
- Task management and quality control

Task 5. Data Evaluation

This task includes efforts related to the analysis of data once it has been verified that the data are of acceptable accuracy and precision. The task begins on the date that the first set of validated data is received by the contractor project team and ends during preparation of the RI report when it is deemed that no additional data are required. The following are typical activities:

- Data evaluation
- Data reduction and tabulation
- Environmental fate and transport modeling/evaluation
- Task management and quality control

Task 6. Assessment of Risks

This task includes efforts related to conducting the baseline risk assessment. The task will include work to assess the potential human health and environmental risks associated with the site. Work will begin during the RI and is completed once the baseline risk assessment is completed.[4] The following are typical activities:

- Identification of contaminants of concern (or indicator chemicals)
- Exposure assessment (including any modeling performed specifically for this function)
- Toxicity assessment
- Risk characterization
- Task management and quality control

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[3] Note that limited fieldwork during project scoping may be authorized as part of the work assignment to prepare the RI/FS work plan.

[4] Limited efforts to assess potential human health and environmental risks are, to some extent, initiated during scoping when the conceptual site model is being developed.

Task 7. Treatability Study/Pilot Testing

This task includes efforts to prepare and conduct pilot, bench, and treatability studies. This task begins with the development of work plans for conducting the tests and is complete once the report has been completed. The following are typical activities:

- Work plan preparation or work plan amendment
- Test facility and equipment procurement
- Vendor and analytical service procurement
- Equipment operation and testing
- Sample analysis and validation
- Evaluation of results
- Report preparation
- Task management and quality control

Task 8. Remedial Investigation Reports

This task covers all efforts related to the preparation of the findings once the data have been evaluated under Tasks 5 and 6. The task covers all draft and final RI reports as well as task management and quality control. The task ends when the last RI document is submitted by the contractor to EPA. The following are typical activities:

- Preparation of a preliminary site characterization summary (see Section 3.7.2 of this guidance)
- Data presentation (formatting tables, preparing graphics)
- Writing the report
- Reviewing and providing QC efforts
- Printing and distributing the report
- Holding review meetings
- Revising the report on the basis of agency comments
- Providing task management and control

Task 9. Remedial Alternatives Development/Screening

This task includes efforts to select the alternatives to undergo full evaluation. The task is initiated once sufficient data are available to develop general response actions and begin the initial evaluation of potential technologies. This task is defined as complete when a final set of alternatives is chosen for detailed evaluation. The following are typical activities:

- Identifying/screening potential technologies
- Assembling potential alternatives
- Identifying action-specific ARARs
- Evaluating each alternative on the basis of screening criteria (effectiveness, implementability, cost)
- Reviewing and providing QC of work effort
- Preparing the report or technical memorandum
- Holding review meetings
- Refining the list of alternatives to be evaluated

Task 10. Detailed Analysis of Remedial Alternatives

This task applies to the detailed analysis and comparison of alternatives. The evaluation activities include performing detailed human health, environmental, and institutional analyses. The task begins when the alternatives to undergo detailed analysis have been identified and agreed upon and ends when the analysis is complete. The following are typical activities:[5]

- Refinement of alternatives
- Individual analysis against the criteria
- Comparative analysis of alternatives against the criteria
- Review of QC efforts
- Review meetings
- Task management and QC

Task 11. Feasibility Study (or RI/FS) Reports

Similar to the RI reports task, this task is used to report FS deliverables. However, this task should be used in lieu of the RI reports task to report costs and schedules for combined RI/FS deliverables. The task ends when the FS (or RI/FS) is released to the public. The following are typical activities:

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[5] State and community acceptance will be evaluated by the lead agency during remedy selection.

- Presenting data (formatting tables, preparing graphics)
- Writing the report
- Printing and distributing the report
- Holding review meetings
- Revising the report on the basis of agency comments
- Providing task management and quality control

Task 12. Post RI/FS Support

This task includes efforts to prepare the proposed plan, the responsiveness summary, support the ROD, conduct any predesign activities, and close out the work assignment. All activities occurring after the release of the FS to the public should be reported under this task. The following are typical activities:

- Preparing the predesign report
- Preparing the conceptual design
- Attending public meetings
- Writing and reviewing the responsiveness summary
- Supporting ROD preparation and briefings
- Reviewing and providing QC of the work effort
- Providing task management and QC

Task 13. Enforcement Support

This task includes efforts during the RI/ FS associated with enforcement aspects of the project. Activities vary but are to be associated with efforts related to PRPs. The following are typical activities:

- Reviewing PRP documents
- Attending negotiation meetings
- Preparing briefing materials
- Assisting in the preparation of ROD
- Providing task management and QC

Task 14. Miscellaneous Support

This task is used to report on work that is associated with the project but is outside the normal RI/FS scope of work. Activities will vary but include the following:

- Specific support for coordination with and review of ATSDR activities and reports
- Support for review of special State or local projects

The following are some specific comments applicable to the 14 tasks described above:

- All standard tasks or all work activities under each task need not be used for every RI/FS. Only those that are relevant to a given project should be used.
- Tasks include both draft and final versions of deliverables unless otherwise noted.
- The phases of a task should be reported in the same task (e.g., field investigation Phase I and Phase II will appear as one field investigation task).
- If an RI/FS is divided into distinct operable units, each operable unit should be monitored and reported on separately. Therefore, an RI/FS with several operable units may, in fact, have more than 15 tasks, although each of the tasks will be one of the 15 standard tasks.
- Costs associated with project management and technical QA are included in each task.
- Costs associated with procuring subcontractors are included in the task in which the subcontractor will perform work (not the project planning task).
- Lists of standard tasks define the minimum level of reporting. For federal-lead tasks, some RPMs and contractors currently report progress in a more detailed fashion and may continue to do so as long as activities are associated with standard tasks.

III. Elements of a Quality Assurance Project Plan

Title Page – At the bottom of the title page, provisions should be made for the signatures of approving personnel. As a minimum, the QAPP must be approved by the following:

- Subcontractor's project manager (if a subcontractor is used)
- Subcontractor's QA manager (if a subcontractor is used)
- Contractor's project manager (if applicable)

- Contractor's QA manager (if applicable)
- Lead agency's project officer
- Lead agency's QA officer (if applicable)

Provision should be made for the approval or review of others (e.g., regional laboratory directors), if applicable.

Table of Contents – The table of contents will include an introduction, a serial listing of the 16 QAPP elements, and a listing of any appendixes that are required to augment the QAPP. The end of the table of contents should include a list of the recipients of official copies of the QAPP.

Project Description – The introduction to the project description consists of a general paragraph identifying the phase of the work and the general objectives of the investigation. A description of the location, size, and important physical features of the site such as ponds, lagoons, streams, and roads should be included (a figure showing the site location and layout is helpful). A chronological site history including descriptions of the use of the site, complaints by neighbors, permitting, and use of chemicals needs to be provided along with a brief summary of previous sampling efforts and an overview of the results. Finally, specific project objectives for this phase of data gathering need to be listed, and ways in which the data will be used to address each of the objectives must be identified. **Those items above that are also included in the work plan need not be repeated in the QAPP and, instead, may be incorporated by reference.**

Project Organization and Responsibilities – This element identifies key personnel or organizations that are necessary for each activity during the study. A table or chart showing the organization and line of authority should be included. When specific personnel cannot be identified, the organization with the responsibility should be listed.

QA Objectives for Measurement – For individual matrix groups and parameters, a cooperative effort should be undertaken by the lead agency, the principal engineering firm, and the laboratory staff to define what levels of quality should be required for the data. These QA objectives will be based on a common understanding of the intended use of the data, available laboratory procedures, and available resources. The field blanks and duplicate field sample aliquots to be collected for QA purposes should be itemized for the matrix groups identified in the project description.

The selection of analytical methods requires a familiarity with regulatory or legal requirements concerning data usage. Any regulations that mandate the use of certain methods for any of the sample matrices and parameters listed in the project description should be specified.

The detection limits needed for the project should be reviewed against the detection limits of the laboratory used. Special attention should be paid to the detection limits provided by the laboratory for volatile organic compounds, because these limits are sometimes insufficient for the analysis of drinking water. Detection limits may also be insufficient to assess attainment of ARARs. For Federal-lead projects, if QA objectives are not met by CLP RASs, then one or more CLP SASs can be written.

Quantitative limits should be established for the following QA objectives:

1. Accuracy of spikes, reference compounds
2. Precision
3. Method detection limits

These limits may be specified by referencing the SOW for CLP analysis, including SAS requests, in an appendix and referring to the appendix or owner/operator manuals for field equipment.

Completeness, representativeness, and comparability are quality characteristics that should be considered during study planning. Laboratories should provide data that meet QC acceptance criteria for 90 percent or more of the requested determinations. Any sample types, such as control or background locations, that require a higher degree of completeness should be identified. "Representativeness" of the data is most often thought of in terms of the collection of representative samples or the selection of representative sample aliquots during laboratory analysis. "Comparability" is a consideration for planning to avoid having to use data gathered by different organizations or among different analytical methods that cannot reasonably be compared because of differences in sampling conditions, sampling procedures, etc.

Sampling Procedures – These procedures append the site-specific sampling plan. Either the sampling plan or the analytical procedures element may document field measurements or test procedures for hydrogeological investigations.

For each major measurement, including pollutant measurement systems, a description of the sampling procedures to be used should be provided. Where applicable, the following should be included:

- A description of techniques or guidelines used to select sampling sites

- A description of the specific sampling procedures to be used
- Charts, flow diagrams, or tables delineating sampling program
- A description of containers, procedures, reagents, and so forth, used for sample collection, preservation, transport, and storage
- A discussion of special conditions for the preparation of sampling equipment and containers to avoid sample contamination
- A description of sample preservation methods
- A discussion of the time considerations for shipping samples promptly to the laboratory
- Examples of the custody or chain-of-custody procedures and forms
- A description of the forms, notebooks, and procedures to be used to record sample history, sampling conditions, and analyses to be performed

The DQO document described above can also be incorporated by reference in this section. In addition, the *Compendium of Superfund Field Operations Methods* (U.S. EPA, September 1987) contains information pertinent to this section and can be incorporated by reference.

Sample Custody – Sample custody is a part of any good laboratory or field operation. If samples were needed for legal purposes, chain-of-custody procedures, as defined by the *NEIC Policies and Procedures* (U.S. EPA, June 1985), would be used. Custody is divided into three parts:

- Sample collection
- Laboratory
- Final evidence files

The QAPP should address all three areas of custody and should refer to the *User's Guide to the Contract Laboratory Program* (U.S. EPA, December 1986) and Regional guidance documents for examples and instructions. For federal-lead projects, laboratory custody is described in the CLP SOW; this may be referenced. Final evidence files include all originals of laboratory reports and are maintained under documented control in a secure area.

A sample or an evidence file is under custody if:

- It is in your possession.
- It is in your view, after being in your possession.
- It was in your possession and you placed it in a secure area.
- It is in a designated secure area.

A QAPP should provide examples of chain-of-custody records or forms used to record the chain of custody for samples, laboratories, and evidence files.

Calibration Procedures – These procedures should be identified for each parameter measured and should include field and laboratory testing. The appropriate standard operating procedures (SOPs) should be referenced, or a written description of the calibration procedures to be used should be provided.

Analytical Procedures – For each measurement, either the applicable SOP should be referenced or a written description of the analytical procedures to be used should be provided. Approved EPA procedures or their equivalent should be used.

Data Reduction, Validation, and Reporting – For each measurement, the data reduction scheme planned for collected data, including all equations used to calculate the concentration or value of the measured parameter, should be described. The principal criteria that will be used to validate the integrity of the data during collection and reporting should be referenced.

Internal Quality Control – All specific internal QC methods to be used should be identified. These methods include the use of replicates, spike samples, split samples, blanks, standards, and QC samples. Ways in which the QC information will be used to qualify the field data should be identified.

Performance and Systems Audits – The QAPP should describe the internal and external performance and systems audits that will be required to monitor the capability and performance of the total measurement system. The current *CLP Invitation for Bids* for organic and inorganic analyses may be referenced for CLP RAS performance and systems audits. The *Compendium of Superfund Field Operations Methods* (U.S. EPA, September 1987) may be referenced for routine fieldwork.

The systems audits consist of the evaluation of the components of the measurement systems to determine their proper selection and use. These audits include a careful evaluation of both field and laboratory QC procedures and are normally performed before or shortly after systems are operational. However, such audits should be performed on a regular schedule during the lifetime of the project or continuing operation. An onsite systems audit may be required for formal laboratory certification programs.

After systems are operational and are generating data, performance audits are conducted periodically to determine the accuracy of the total measurement system or its component parts. The QAPP should include a schedule for conducting performance audits for each measurement parameter. Laboratories may be required to participate in the analysis of performance evaluation samples related to specific projects. Project plans should also indicate, where applicable, scheduled participation in all other interlaboratory performance evaluation studies.

In support of performance audits, the environmental monitoring systems and support laboratories provide necessary audit materials and devices, as well as technical assistance. These laboratories conduct regular interlaboratory performance tests and provide guidance and assistance in the conduct of systems audits. The laboratories should be contacted if assistance is needed in the above areas.

Preventive Maintenance – A schedule should be provided of the major preventative maintenance tasks that will be carried out to minimize downtime of field and laboratory instruments. Owner's manuals may be referenced for field equipment.

Specific Routine Procedures Used to Assess Data (Precision, Accuracy, and Completeness) – The precision and accuracy of data must be routinely assessed for all environmental monitoring and measurement data. The QAPP should describe specific procedures to accomplish this assessment. If enough data are generated, statistical procedures may be used to assess the precision, accuracy, and completeness. If statistical procedures are used, they should be documented.

Corrective Actions – In the context of QA, corrective actions are procedures that might be implemented on samples that do not meet QA specifications. Corrective actions are usually addressed on a case-by-case basis for each project. The need for corrective actions is based on predetermined limits for acceptability. Corrective actions may include resampling, reanalyzing samples, or auditing laboratory procedures. The QAPP should identify persons responsible for initiating these actions, procedures for identifying and documenting corrective actions, and procedures for reporting and followup.

Quality Assurance Project Plans – QAPPs should identify the method to be used to report the performance of measurement systems and data quality. This reporting should include results of performance audits, results of systems audits, and significant QA problems encountered, along with recommended solutions. The RI report should include a separate QA section that summarizes the data quality.

IV. Elements of a Field Sampling Plan[6]

Site Background – If the analysis of existing data is not included in the work plan or QAPP, it must be included in the FSP. This analysis would include a description of the site and surrounding areas and a discussion of known and suspected contaminant sources, probable transport pathways, and other information about the site. The analysis should also include descriptions of specific data gaps and ways in which sampling is designed to fill those gaps. Including this discussion in the FSP will help orient the sampling team in the field.

Sampling Objectives – Specific objectives of a sampling effort that describe the intended uses of data should be clearly and succinctly stated.

Sample Location and Frequency – This section of the sampling plan identifies each sample matrix to be collected and the constituents to be analyzed. A table may be used to clearly identify the number of samples to be collected along with the appropriate number of replicates and blanks. A figure should be included to show the locations of existing or proposed sample points.

Sample Designation – A sample numbering system should be established for each project. The sample designation should include the sample or well number, the sampling round, the sample matrix (e.g., surface soil, ground water, soil boring), and the name of the site.

Sampling Equipment and Procedures – Sampling procedures must be clearly written. Step-by-step instructions for each type of sampling are necessary to enable the field team to gather data that will meet the DQOs. A list should include the equipment to be used and the material composition (e.g., Teflon, stainless steel) of the equipment along with decontamination procedures.

Sample Handling and Analysis – A table should be included that identifies sample preservation methods, types of sampling jars, shipping requirements, and holding times. SAS requests and CLP SOWs may be referenced for some of this information.

Examples of paperwork and instructions for filling out the paperwork should be included. Use of the CLP requires that traffic reports, chain-of-custody forms, SAS packing lists, and sample tags be filled out for each sample. If other laboratories are to be used, the specific documentation required should be identified. Field documentation includes field notebooks and photographs.

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[6] Field sampling plans are site-specific and may include additional elements.

Provision should be made for the proper handling and disposal of wastes generated onsite. The site-specific procedures need to be described to prevent contamination of clean areas and to comply with existing regulations.

V. Elements of a Health and Safety Plan

1. The name of a site health and safety officer and the names of key personnel and alternates responsible for site safety and health
2. A health and safety risk analysis for existing site conditions, and for each site task and operation
3. Employee training assignments
4. A description of personal protective equipment to be used by employees for each of the site tasks and operations being conducted
5. Medical surveillance requirements
6. A description of the frequency and types of air monitoring, personnel monitoring, and environmental sampling techniques and instrumentation to be used
7. Site control measures
8. Decontamination procedures
9. Standard operating procedures for the site
10. A contingency plan that meets the requirements of 29 CFR 1910.120(l)(1) and (l)(2)
11. Entry procedures for confined spaces

Appendix C

Model Statement of Work for Remedial Investigations and Feasibility Studies

Introduction

This model statement of work (SOW) was developed to provide users of this guidance with an illustrative example of how the specific tasks[1] carried out during a remedial investigation (RI) and feasibility study (FS) may be presented. Because an RI/FS is phased in accordance with a site's complexity and the amount of available information, it may be necessary to modify components of the SOW in order to tailor the tasks to the specific conditions at a site. Similarly, the level of detail and the specification of individual tasks will vary according to the budget, size, and complexity of the contract. Therefore, a SOW may differ, or additional tasks may be added to what is presented here.

A SOW should begin with a section identifying the site, its regulatory history, if any, and a statement and discussion of the purpose and objectives of the RI/FS within the context of that particular site. This section should be followed by a discussion of the specific tasks that will be necessary to meet the stated objectives. The SOW should be accompanied by U.S. EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, October 1988).

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[1] REM contractor standard tasks have been developed for cost accounting purposes (see Appendix B) and are the basis of the format of this model SOW.

Model SOW for Conducting an RI/FS

Purpose

The purpose of this remedial investigation/feasibility study (RI/FS) is to investigate the nature and extent of contamination at the OTR site and to develop and evaluate remedial alternatives, as appropriate. The contractor will furnish all necessary personnel, materials, and services needed for, or incidental to, performing the RI/FS, except as otherwise specified herein. The contractor will conduct the RI/FS in accordance with the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (U.S. EPA, October 1988).

This statement of work (SOW) has been developed for the OTR site that operated as a former drum recycling center from 1968 through 1979. OTR was proposed for inclusion to the NPL in September 1980 and appeared as final on the NPL in September 1981. A removal action taken in 1982 removed all visible drums and disposed of them in an offsite landfill. Three buildings remain onsite along with visibly stained soil that is assumed to be contaminated with TCE, benzene, and other organics. It is suspected that releases from the site have contaminated nearby surface waters and ground waters beneath the site.

Scope

The specific RI/FS activities to be conducted at the OTR site are segregated into 11 separate tasks.

- Task 1 – Project Planning
- Task 2 – Community Relations
- Task 3 – Field Investigations
- Task 4 – Sample Analysis/Validation
- Task 5 – Data Evaluation
- Task 6 – Risk Assessment
- Task 7 – Treatability Studies
- Task 8 – RI Report(s)
- Task 9 – Remedial Alternatives Development and Screening
- Task 10 – Detailed Analysis of Alternatives
- Task 11 – FS Report(s)

The contractor shall specify a schedule of activities and deliverables, a budget estimate, and staffing requirements for each of the tasks which are described below.

Task 1 Project Planning

Upon receipt of an interim authorization memorandum (used to authorize work plan preparation) and this SOW from U.S. EPA outlining the general scope of the project, the contractor shall begin planning the specific RI/FS activities that will need to be conducted. As part of this planning effort, the contractor will compile existing information (e.g., topographic maps, aerial photographs, data collected as part of the NPL listing process, and data collected as part of the drum removal of 1982) and conduct a site visit to become familiar with site topography, access routes, and the proximity of potential receptors to site contaminants. Based on this information (and any other available data), the contractor will prepare a site background summary that should include the following:

- *Local Regional Summary* – A summary of the location of the site, pertinent area boundary features and general site physiography, hydrology, geology, and the location(s) of any nearby drinking water supply wells.
- *Nature and Extent of Problem* – A summary of the actual and potential onsite and offsite health and environmental effects posed by any remaining contamination at the site. Emphasis should be on providing a conceptual understanding of the sources of contamination, potential release mechanisms, potential routes of migration, and potential human and environmental receptors.
- *History of Regulatory and Response Actions* – A summary of any previous response actions conducted by local, State, Federal, or private

parties. This summary should address any enforcement activities undertaken to identify responsible parties, compel private cleanup, and recover costs. Site reference documents and their locations should be identified.

- *Preliminary Site Boundary* – A preliminary site boundary to define the initial area(s) of the remedial investigation. This preliminary boundary may also be used to define an area of access control and site security.

The contractor will meet with EPA to discuss the following:

- The proposed scope of the project and the specific investigative and analytical activities that will be required
- Whether there is a need to conduct limited sampling to adequately scope the project and develop project plans
- Preliminary remedial action objectives and general response actions
- Potential remedial technologies and the need for or usefulness of treatability studies
- Potential ARARs associated with the location and contaminants of the site and the potential response actions being contemplated
- Whether a temporary site office should be set up to support site work

Once the scope has been agreed upon with EPA, the contractor will (1) develop the specific project plans to meet the objectives of the RI/FS[2] and (2) initiate subcontractor procurement and coordination with analytical laboratories. The project plans will include: a work plan which provides a project description and outlines the overall technical approach, complete with corresponding personnel requirements, activity schedules, deliverable due dates, and budget estimates for each of the specified tasks; a sampling and analysis plan [composed of the field sampling plan (FSP) and the quality assurance project plan (QAPP)]; a health and safety plan; and a community relations plan. The latter three plans are described below.

Sampling and Analysis Plan – The contractor will prepare a SAP which will consist of the following:

Field Sampling Plan. The FSP should specify and outline all necessary activities to obtain additional site data. It should contain an evaluation explaining what additional data are required to adequately characterize the site, conduct a baseline risk assessment, and support the evaluation of remedial technologies in the FS. The FSP should clearly state sampling objectives; necessary equipment; sample types, locations, and frequency; analyses of interest; and a schedule stating when events will take place and when deliverables will be submitted.

Quality Assurance Project Plan. The QAPP should address all types of investigations conducted and should include the following discussions:

- A project description (should be duplicated from the work plan)
- A project organization chart illustrating the lines of responsibility of the personnel involved in the sampling phase of the project
- Quality assurance objectives for data such as the required precision and accuracy, completeness of data, representativeness of data, comparability of data, and the intended use of collected data
- Sample custody procedures during sample collection, in the laboratory, and as part of the final evidence files
- The type and frequency of calibration procedures for field and laboratory instruments, internal quality control checks, and quality assurance performance audits and system audits
- Preventative maintenance procedures and schedule and corrective action procedures for field and laboratory instruments
- Specific procedures to assess data precision, representativeness, comparability, accuracy, and completeness of specific measurement parameters
- Data documentation and tracking procedures

Standard operating procedures for QA/QC that have been established within EPA will be referenced and not duplicated in the QAPP.

Health and Safety Plan – The contractor will develop an HSP on the basis of site conditions to protect personnel involved in site activities and the surrounding community. The plan should address all applicable regulatory requirements contained in 20 CFR 1910.120(i)(2) – Occupational Health and Safety Administration, Hazardous Waste Operations and Emergency Response, Interim Rule, December 19, 1986; U.S. EPA Order 1440.2 – Health and Safety

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[2] At some sites it may be necessary to submit an interim work plan initially until more is learned about the site. A subsequent, more thorough project planning effort can then be used to develop final workplans.

Requirements for Employees Engaged in Field Activities; U.S. EPA Order 1440.3 – Respiratory Protection; U.S. EPA Occupational Health and Safety Manual; and U.S. EPA Interim Standard Operating Procedures (September, 1982). The plan should provide a site background discussion and describe personnel responsibilities, protective equipment, health and safety procedures and protocols, decontamination procedures, personnel training, and type and extent of medical surveillance. The plan should identify problems or hazards that may be encountered and how these are to be addressed. Procedures for protecting third parties, such as visitors or the surrounding community, should also be provided. **Standard operating procedures for ensuring worker safety should be referenced and not duplicated in the HSP.**

Community Relations Plan – The contractor will prepare a community relations plan on how citizens want to be involved in the process based on interviews with community representatives and leaders. The CLP will describe the types of information to be provided to the public and outline the opportunities for community comment and input during the RI/FS. Deliverables, schedule, staffing, and budget requirements should be included in the plan.

The work plan and corresponding activity plans will be submitted to EPA as specified in the contract or as discussed in the initial meeting(s). The contractor will provide a quality review of all project planning deliverables.

Task 2 Community Relations

The contractor will provide the personnel, services, materials, and equipment to assist EPA in undertaking a community relations program. This program will be integrated closely with all remedial response activities to ensure community understanding of actions being taken and to obtain community input on RI/FS progress. Community relations support provided by the contractor will include, but may not be limited to, the following:

- Revisions or additions to community relations plans, including definition of community relations program needs for each remedial activity
- Establishment of a community information repository(ies), one of which will house a copy of the administrative record
- Preparation and dissemination of news releases, fact sheets, slide shows, exhibits, and other audio-visual materials designed to apprise the community of current or proposed activities
- Arrangements of briefings, press conferences, workshops, and public and other informal meetings
- Analysis of community attitudes toward the proposed actions
- Assessment of the successes and failures of the community relations program to date
- Preparation of reports and participation in public meetings, project review meetings, and other meetings as necessary for the normal progress of the work
- Solicitation, selection, and approval of subcontractors, if needed

Deliverables and the schedule for submittal will be identified in the community relations plan discussed under Task 1.

Task 3 Field Investigations

The contractor will conduct those investigations necessary to characterize the site and to evaluate the actual or potential risk to human health and the environment posed by the site. Investigation activities will focus on problem definition and result in data of adequate technical content to evaluate potential risks and to support the development and evaluation of remedial alternatives during the FS. The aerial extent of investigation will be finalized during the remedial investigation.

Site investigation activities will follow the plans developed in Task 1. Strict chain-of-custody procedures will be followed and all sample locations will be identified on a site map. The contractor will provide management and QC review of all activities conducted under this task. Activities anticipated for this site are as follows:

- *Surveying and Mapping of the Site*[3] – Develop a map of the site that includes topographic information and physical features on and near the site. If no detailed topographic map for the site and surrounding area exists, a survey of the site will be conducted. Aerial photographs should be used, when available, along with information gathered during the preliminary site visit to identify physical features of the area.
- *Waste Characterization* – Determine the location, type, and quantities as well as the physical or chemical characteristics of any waste remaining at the site. If hazardous substances are held in

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[3] May be conducted under Task 1 as part of the site visit or limited investigation.

containment vessels, the integrity of the containment structure and the characteristics of the contents will be determined.

- *Hydrogeologic Investigation* – Determine the presence and potential extent of ground water contamination. Efforts should begin with a survey of previous hydrogeologic studies and other existing data. The survey should address the soil's retention capacity/mechanisms, discharge/recharge areas, regional flow directions and quality, and the likely effects of any alternatives that are developed involving the pumping and disruption of ground water flow. Results from the sampling program should estimate the horizontal and vertical distribution of contaminants, the contaminants' mobility, and predict the long-term disposition of contaminants.
- *Soils and Sediments Investigation* – Determine the vertical and horizontal extent of contamination of surface and subsurface soils and sediments and identify any uncertainties with this analysis. Information on local background levels, degree of hazard, location of samples, techniques used, and methods of analysis should be included. If initial efforts indicate that buried waste may be present, the probable locations and quantities of these subsurface wastes should be identified through the use of appropriate geophysical methods.
- *Surface Water Investigation* – Estimate the extent and fate of any contamination in the nearby surface waters. This effort should include an evaluation of possible future discharges and the degree of contaminant dilution expected.
- *Air Investigation* – Investigate the extent of atmospheric contamination from those contaminants found to be present at the site. This effort should assess the potential of the contaminants to enter the atmosphere, local wind patterns, and the anticipated fate of airborne contaminants.

Information from this task will be summarized and included in the RI/FS report appendixes.

Task 4 Sample Analysis/Validation

The contractor will develop a data management system including field logs, sample management and tracking procedures, and document control and inventory procedures for both laboratory data and field measurements to ensure that the data collected during the investigation are of adequate quality and quantity to support the risk assessment and the FS. Collected data should be validated at the appropriate field or laboratory QC level to determine whether it is appropriate for its intended use. Task management and quality controls will be provided by the contractor. The contractor will incorporate information from this task into the RI/FS report appendixes.

Task 5 Data Evaluation

The contractor will analyze all site investigation data and present the results of the analyses in an organized and logical manner so that the relationships between site investigation results for each medium are apparent. The contractor will prepare a summary that describes (1) the quantities and concentrations of specific chemicals at the site and the ambient levels surrounding the site; (2) the number, locations, and types of nearby populations and activities; and (3) the potential transport mechanism and the expected fate of the contaminant in the environment.

Task 6 Risk Assessment

The contractor shall conduct a baseline risk assessment to assess the potential human health and environmental risks posed by the site in the absence of any remedial action. This effort will involve four components: contaminant identification, exposure assessment, toxicity assessment, and risk characterization.

- *Contaminant Identification* – The contractor will review available information on the hazardous substances present at the site and identify the major contaminants of concern. Contaminants of concern should be selected based on their intrinsic toxicological properties because they are present in large quantities, and/or because they are currently in, or potentially may migrate into, critical exposure pathways (e.g., drinking water).
- *Exposure Assessment* – The contractor will identify actual or potential exposure pathways, characterize potentially exposed populations, and evaluate the actual or potential extent of exposure.
- *Toxicity Assessment* – The contractor will provide a toxicity assessment of those chemicals found to be of concern during site investigation activities. This will involve an assessment of the types of adverse health or environmental effects associated with chemical exposures, the relationships between magnitude of exposures and adverse effects, and the related uncertainties for contaminant toxicity, (e.g., weight of evidence for a chemical's carcinogenicity).
- *Risk Characterization* – The contractor will integrate information developed during the exposure and toxicity assessments to characterize the current or potential risk to human health and/or the environment posed by the site. This characterization should identify the potential

for adverse health or environmental effects for the chemicals of concern and identify any uncertainties associated with contaminant(s), toxicity(ies), and/or exposure assumptions.

The risk assessment will be submitted to EPA as part of the RI report.

Task 7 Treatability Studies

The contractor will conduct bench and/or pilot studies as necessary to determine the suitability of remedial technologies to site conditions and problems. Technologies that may be suitable to the site should be identified as early as possible to determine whether there is a need to conduct treatability studies to better estimate costs and performance capabilities. Should treatability studies be determined to be necessary, a testing plan identifying the types and goals of the studies, the level of effort needed, a schedule for completion, and the data management guidelines should be submitted to EPA for review and approval. Upon EPA approval, a test facility and any necessary equipment, vendors, and analytical services will be procured by the contractor.

Upon completion of the testing, the contractor will evaluate the results to assess the technologies with respect to the goals identified in the test plan. A report summarizing the testing program and its results should be prepared by the contractor and presented in the final RI/FS report. The contractor will implement all management and QC review activities for this task.

Task 8 RI Report

Monthly reports will be prepared by the contractor to describe the technical and financial progress at the OTR site. Each month the following items will be reported:

- Status of work and the progress to date
- Percentage of the work completed and the status of the schedule
- Difficulties encountered and corrective actions to be taken
- The activity(ies) in progress
- Activities planned for the next reporting period
- Any changes in key project personnel
- Actual expenditures (including fee) and direct labor hours for the reporting period and for the cumulative term of the project
- Projection of expenditures needed to complete the project and an explanation of significant departures from the original budget estimate

Monthly reports will be submitted to U.S. EPA as specified in the contract. In addition, the activities conducted and the conclusions drawn during the remedial investigation (Tasks 3 through 7) will be documented in an RI report (supporting data and information should be included in the appendixes of the report). The contractor will prepare and submit a draft RI report to EPA for review. Once comments on the draft RI report are received, the contractor will prepare a final RI report reflecting these comments.

Task 9 Remedial Alternatives Development and Screening

The contractor will develop a range of distinct, hazardous waste management alternatives that will remediate or control any contaminated media (soil, surface water, ground water, sediments) remaining at the site, as deemed necessary in the RI, to provide adequate protection of human health and the environment. The potential alternatives should encompass, as appropriate, a range of alternatives in which treatment is used to reduce the toxicity, mobility, or volume of wastes but vary in the degree to which long-term management of residuals or untreated waste is required, one or more alternatives involving containment with little or no treatment; and a no-action alternative. Alternatives that involve minimal efforts to reduce potential exposures (e.g., site fencing, deed restrictions) should be presented as "limited action" alternatives.

The following steps will be conducted to determine the appropriate range of alternatives for this site:

- *Establish Remedial Action Objectives and General Response Actions*[4] – Based on existing information, site-specific remedial action objectives to protect human health and the environment should be developed. The objectives should specify the contaminant(s) and media of concern, the exposure route(s) and receptor(s), and an acceptable contaminant level or range of levels for each exposure route (i.e., preliminary remediation goals).

Preliminary remediation goals should be established based on readily available information (e.g., Rfds) or chemical-specific ARARs (e.g., MCLs). The contractor should meet with EPA to discuss the remedial action objectives for the site. As more information is collected during the RI, the contractor, in consultation with EPA, will refine remedial action objectives as appropriate.

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[4] Preliminary remedial action objectives are developed as part of the project planning phase.

General response actions will be developed for each medium of interest defining contaminant, treatment, excavation, pumping, or other actions, singly or in combination to satisfy remedial action objectives. Volumes or areas of media to which general response actions may apply shall be identified, taking into account requirements for protectiveness as identified in the remedial action objectives and the chemical and physical characteristics of the site.

- *Identify and Screen Technologies* – Based on the developed general response actions, hazardous waste treatment technologies should be identified and screened to ensure that only those technologies applicable to the contaminants present, their physical matrix, and other site characteristics will be considered. This screening will be based primarily on a technology's ability to effectively address the contaminants at the site, but will also take into account a technology's implementability and cost. The contractor will select representative process options, as appropriate, to carry forward into alternative development. The contractor will identify the need for treatability testing (as described under Task 7) for those technologies that are probable candidates for consideration during the detailed analysis.
- *Configure and Screen Alternatives* – The potential technologies and process options will be combined into media-specific or sitewide alternatives. The developed alternatives should be defined with respect to size and configuration of the representative process options; time for remediation; rates of flow or treatment; spatial requirements; distances for disposal; and required permits, imposed limitations, and other factors necessary to evaluate the alternatives. If many distinct, viable options are available and developed, a screening of alternatives will be conducted to limit the number of alternatives that undergo the detailed analysis and to provide consideration of the most promising process options. The alternatives should be screened on a general basis with respect to their effectiveness, implementability, and cost. The contractor will meet with EPA to discuss which alternatives will be evaluated in the detailed analysis and to facilitate the identification of action-specific ARARs.

Task 10 Detailed Analysis of Alternatives

The contractor will conduct a detailed analysis of alternatives which will consist of an individual analysis of each alternative against a set of evaluation criteria and a comparative analysis of all options against the evaluation criteria with respect to one another.

The evaluation criteria are as follows:

- *Overall Protection of Human Health and the Environment* addresses whether or not a remedy provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.
- *Compliance with ARARs* addresses whether or not a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statutes and/or provide grounds for invoking a waiver.
- *Long-Term Effectiveness and Permanence* refers to the ability of a remedy to maintain reliable protection of human health and the environment over time once cleanup goals have been met.
- *Reduction of Toxicity, Mobility, or Volume Through Treatment* is the anticipated performance of the treatment technologies a remedy may employ.
- *Short-Term Effectiveness* addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.
- *Implementability* is the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.
- *Cost* includes estimated capital and operation and maintenance costs, and net present worth costs.
- *State Acceptance*[5] (Support Agency) addresses the technical or administrative issues and concerns the support agency may have regarding each alternative.
- *Community Acceptance*[5] addresses the issues and concerns the public may have to each of the alternatives.

The individual analysis should include: (1) a technical description of each alternative that outlines the waste management strategy involved and identifies the key

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[5] These criteria will be addressed in the ROD once comments on the RI/FS report and proposed plan have been received and will not be included in the RI/FS report..

ARARs associated with each alternative; and (2) a discussion that profiles the performance of that alternative with respect to each of the evaluation criteria. A table summarizing the results of this analysis should be prepared. Once the individual analysis is complete, the alternatives will be compared and contrasted to one another with respect to each of the evaluation criteria.

Task 11 FS Report(s)

Monthly contractor reporting requirements for the FS are the same as those specified for the RI under Task 8.

The contractor will present the results of Tasks 9 and 10 in a FS report. Support data, information, and calculations will be included in appendixes to the report. The contractor will prepare and submit a draft FS report to EPA for review. Once comments on the draft FS have been received, the contractor will prepare a final FS report reflecting the comments.[6] Copies of the final report will be made and distributed to those individuals identified by EPA.

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[6] The final FS report may be bound with the final RI report.

Appendix D

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I. Containment Technologies

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Appendix E
Documentation of ARARs

The accompanying table presents a suggested format for summarizing the identification and documentation of ARARs in the RI/FS process. This format assumes that two previous ARARs identification steps have taken place during the RI/FS. First, it assumes that a list of Federal and State ARARs has been developed through consultations between the lead and support agencies. This list should include chemical-, location-, and action-specific requirements and, in the case of multiple ARARs (e.g., both a Federal and State requirement for a particular chemical), the ARAR to be used for the site or alternative (generally the more stringent) should be specified. Second, it assumes that the key requirements and the reasons for their applicability or relevance and appropriateness have been integrated into the narrative descriptions of each alternative as part of the "Detailed Analysis" chapter in the FS report. This appendix, therefore, serves as a summary of the ARARs for each alternative and indicates whether the alternative is anticipated to meet those ARARs, or, if not, what type of waiver would be justified.

The suggested format for the documentation of ARARs is presented here in the form of an example. The example is intended for illustrative purposes only; the ARARs identified for the sample alternatives may not be appropriate in a specific site situation.

The site in the example was a battery and cleaning solution storage facility operated and closed prior to the effective date of the RCRA hazardous waste storage regulations. The site is also located in a floodplain. The site consists of two areas of contaminated soil: Area 1 is contaminated with lead; Area 2 is contaminated with TCE. There is also a ground water plume associated with the site that contains levels of TCE as high as 100 ppb and lead as high as 500 ppb.The alternatives evaluated in detail for the site are:

- Alternative 1 – No action
- Alternative 2 – Capping of the contaminated soil; natural attenuation of the ground water
- Alternative 3 – In situ soil vapor extraction of the TCE-contaminated soil; capping of the lead-contaminated soil; ground water pump/treat with offsite discharge to a nearby creek
- Alternative 4 – In situ soil vapor extraction of the TCE-contaminated soil; in situ fixation of the lead–contaminated area, followed by a soil cap; ground water pump/treat with offsite discharge to a nearby creek
- Alternative 5 – Incineration of the TCE-contaminated soil; offsite disposal of nonhazardous ash in the Subtitle D facility; in situ fixation of the lead-contaminated soil, followed by a soil cap; ground water pump/treat with off site discharge to a nearby creek

For this example, it has been assumed that the TCE is not an RCRA–listed or characteristic waste but that the lead-contaminated area is hazardous because of its characteristic of EP toxicity. Following in-situ fixation, the lead-contaminated soil is anticipated to be nonhazardous. Because none of the alternatives involves the placement of RCRA hazardous waste (lead-contaminated soil), the land disposal restrictions are assumed to be neither applicable nor relevant and appropriate.

The example also assumes that post-closure care requirements of RCRA (e.g., ground water monitoring) will generally be relevant and appropriate wherever closure is performed with waste in place.

Finally, it is also assumed that the RCRA location standards, while not applicable because none of the alternatives involve RCRA–regulated treatment, storage, or disposal, are nonetheless relevant and appropriate to all the action alternatives. Typically, the rationale for determinations of applicability or relevance and appropriateness will be integrated into the description of alternatives in the detailed analysis of the FS report.

The following table identifies the applicable or relevant and appropriate requirements for each of the five alternatives, indicates whether the alternative is expected to achieve that standard, and notes any ARAR waivers that may be required.

Table E-1. Documentation of ARARS

Chemical-Specific	Alternative 1 No Action	Alternative 2 Cap Natural Attenuation	Alternative 3 In Situ SVE of TCE, Cap Lead Area, GW Pump/Treat	Alternative 4 In Situ SVE of TCE, In Situ Fixation, Cap of Lead Area, GW Pump/Treat	Alternative 5 Incineration of TCE Soil/Offsite Disposal of Ash, In Situ Fixation, Cap of Lead Area, GW Pump/Treat
TCE	5 ppb Federal MCL will not be achieved in ground water; no waiver is justified	5 ppb Federal MCL will be met in 30 years	5 ppb Federal MCL will be met in 10 years	See Alternative 3	See Alternative 3
Lead	Neither 50 ppb Federal MCL nor State standard of 20 ppb will be achieved in ground water; no waiver is justified	50 ppb Federal MCL will be met in 30 years; State standard of 20 ppb will not be met; technical impracticability waiver justified	50 ppb Federal MCL will be met in 10 years; State Standard of 20 ppb will not be met; technical impracticability waiver justified	See Alternative 3	See Alternative 3

Table E-1. Continued

Location-Specific	Alternative 1 No Action	Alternative 2 Cap Natural Attenuation	Alternative 3 In Situ SVE of TCE, Cap Lead Area, GW Pump/Treat	Alternative 4 In Situ SVE of TCE, In Situ Fixation, Cap of Lead Area, GW Pump/Treat	Alternative 5 Incineration of TCE Soil/Offsite Disposal of Ash, In Situ Fixation, Cap of Lead Area, GW Pump/Treat
I. RCRA location of TSD facility in 100-year floodplain (40 CFR 264.18)	--	Will meet	See Alternative 2	See Alternative 2	See Alternative 2
II. Executive Order 11988 (Floodplain Management) Evaluate potential effects of actions, avoid adverse impacts to the extent possible (40 CFR 6, Appendix A)	--	Will meet	See Alternative 2	See Alternative 2	See Alternative 2
III. State siting standard for new incinerators	--	--	--	--	Will meet substantive requirements of incinerator standards

Table E-1. Continued

Action-Specific	Alternative 1 No Action	Alternative 2 Cap Natural Attenuation	Alternative 3 In Situ SVE of TCE, Cap Lead Area, GW Pump/Treat	Alternative 4 In Situ SVE of TCE, In Situ Fixation, Cap of Lead Area, GW Pump/Treat	Alternative 5 Incineration of TCE Soil/Offsite Disposal of Ash, In Situ Fixation, Cap of Lead Area, GW Pump/Treat
I. Resource Conservation and Recovery Act (RCRA) as amended by Hazardous and Solid Waste Amendments (HSWA) (42 USCA 7401-7642)					
A. Closure and Post-Closure					
1. Clean Closure (40 CFR 264.111)	--	--	Will meet in Area 2 (TCE area)	Will meet in Area 2 (TCE area)	Will meet in Area 2 (TCE area)
2. Closure With Waste in Place (capping) (40 CFR 264.228)	Will not meet; no waiver is justified	Will meet	--	--	--
3. Post-Closure Care (40 CFR 264.310)	Will not meet; no waiver is justified	Will meet	--	--	--
B. Incineration (40 CFR 264.340-345)	--	--	--	--	Performance standards will be met by onsite incinerator

Table E-1. Continued

Action-Specific	Alternative 1 No Action	Alternative 2 Cap Natural Attenuation	Alternative 3 In Situ SVE of TCE, Cap Lead Area, GW Pump/Treat	Alternative 4 In Situ SVE of TCE, In Situ Fixation, Cap of Lead Area, GW Pump/Treat	Alternative 5 Incineration of TCE Soil/Offsite Disposal of Ash, In Situ Fixation, Cap of Lead Area, GW Pump/Treat
C. Solid Waste Disposal (40 CFR 241.200-212)	--	--	Will meet in Area 1	See Alternative 3	Non-hazardous residuals from incineration of TCE area will be disposed in an offsite Subtitle D facility; fixed lead will be capped
II. Clean Water Act (CWA) (33 USCA 1251 - 1376)					
A. National Pollutant Discharge Elimination System (NPDES) (40 CFR 122 - 125)	--	--	Permit for offsite discharge will be obtained	See Alternative 3	See Alternative 3
B. Water Quality Standards (CWA 402 (a)(1))	--	--	Compliance will occur by meeting NPDES limitations	See Alternative 3	See Alternative 3

Appendix F
Case Example of Detailed Analysis

Introduction

Purpose

This appendix provides an example of how the results of the individual and comparative analyses of remedial alternatives may be presented in the FS report. As discussed in Chapter 6 of this guidance, the individual analysis consists of a narrative description of the alternative including a discussion of how the alternative performs with respect to each of the evaluation criteria[1] The comparative analysis that follows the individual analysis consists of a narrative discussion summarizing the relative performance of the alternatives in relation to one another.

The amount of information presented in a detailed analysis will depend on the complexity of the site and on the extent of investigations and analysis conducted. In addition, as noted in Chapter 6, the level of detail and extent of discussion for the individual subfactors under each criterion will vary based on the relevance of that particular criterion to the alternatives being considered and the scope of the action being taken. Therefore, the amount of detail required to adequately document the results of the evaluations and the specific subfactors that will actually be discussed may differ somewhat from that presented in this case example.

The reader should also keep in mind that an actual RI/FS report will typically include maps, plans, schematics, and cost details that would be presented in previous chapters of the report (e.g., Development and Screening of Alternatives) or in the detailed analysis chapter itself. The purpose of this particular example is to give readers an idea of the types of information that should be provided when describing individual alternatives and discussing their performance against the evaluation criteria.

Site Background

The site used in this example is an old battery and cleaning solution storage facility located in a rural area. Improper handling and storage activities at this site from 1968 to 1978 resulted in both soil and ground water contamination. The area of contamination referred to as Area 1 contains 25,000 cubic yards (cy) of contaminated soil with concentrations of lead exceeding 200 mg/kg (concentrations of lead reach 500 mg/kg at several locations within this area). There is also a discrete area of approximately 20,000 cy of TCE-contaminated soil at the site referred to as Area 2. Analysis of soil samples from this area show TCE concentrations up to 6 percent and slightly elevated levels of metals compared to background. Although the risk assessment did not identify a human health or environmental risk from these metals, there is a small possibility that hot spots of metal contamination may have been missed. The soils of both Areas 1 and 2 are fairly permeable. Figure F-1 presents a simplistic map of the site.

The affected aquifer is shallow, with the water table lying approximately 12 feet under the site, and is currently used for drinking water. This aquifer has the characteristics of a Class IIA aquifer as defined under U.S. EPA's Ground Water Classification System. The aquifer consists of fractured bedrock, making ground water containment technologies difficult to implement. Ground water extraction may also be difficult due to the fractured bedrock. A plume of TCE above the 5 mg/l Maximum Contaminant Level (MCL) (measured as high as 50 ppm) is estimated to be moving in the direction of residential wells at an interstitial velocity of 65 ft/yr. The nearest residential well is 600 feet from the site boundary and the plume of contaminated ground water is likely to reach the well in an estimated 1 to 3 years at concentrations exceeding federal drinking water standards. Sampling conducted during the RI shows that no existing residential wells are currently contaminated.

The exposure pathways of concern identified during the baseline risk assessment include direct contact with possible ingestion of contaminated soil (1 × 10^{-3} associated excess cancer risk), and potential ingestion of contaminated ground water in the future

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[1] The criteria are discussed in the following order: overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. Community and state acceptance will generally not be addressed until the ROD, following receipt of formal comments on the RI/FS report and the proposed plan.

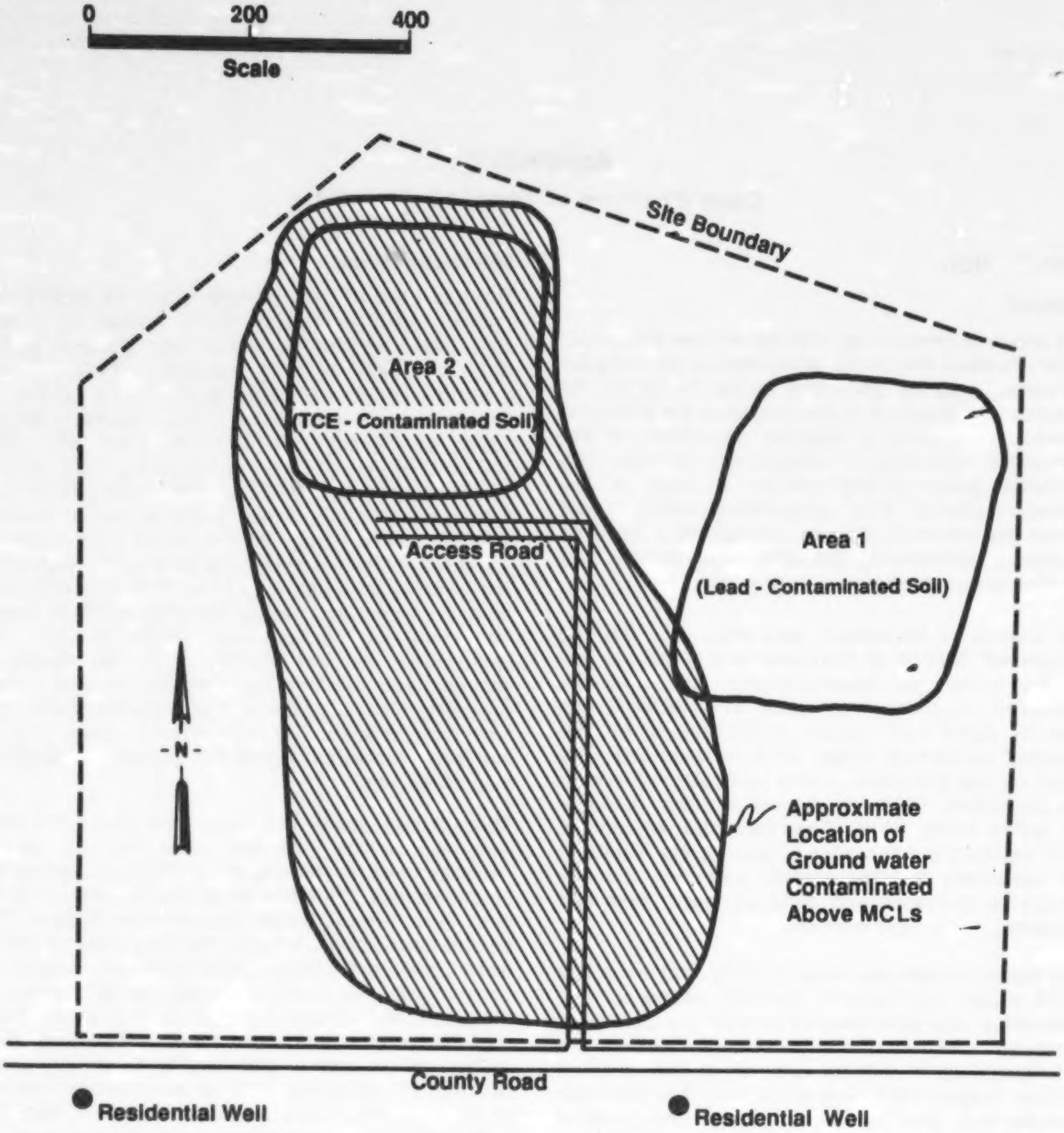
0
200
400
Scale
Site Boundary
Area 2
(TCE - Contaminated Soil)
Access Road
Area 1
(Lead - Contaminated Soil)
- N -
Approximate Location of Ground water Contaminated Above MCLs
County Road
Residential Well
Residential Well

Figure F-1. Site map case example.

through existing or newly installed offsite wells (2 x 10^{-2} associated excess cancer risk). The MCL for TCE (5 µg/l) has been determined to be a relevant and appropriate remediation level for the contaminated ground water at this site since the ground water is used for drinking water. Based on the site-specific risk assessment, the MCL was determined to be sufficiently protective as the aquifer remediation goal.

The risk assessment also concluded that 200 mg/kg for lead in soil would be a protective level for expected site exposures along with a 1 x 10^{-6}

excess cancer risk level for TCE-contaminated soil (56 ppm). Based on investigations of activities at the site, the TCE-contaminated soil has not been determined to be a listed, RCRA hazardous waste since the cleaning solution records indicate the solutions contained less than 10 percent TCE. However, the lead-contaminated soil is an RCRA hazardous waste by characteristic in this instance due to EP-toxicity. None of the waste is believed to have been disposed at the site after November 19, 1980 (the effective date for most of the RCRA treatment, storage, and disposal requirements).

The site is located in a state with an authorized RCRA program for closure which subsumes Federal requirements and specifies more stringent state requirements. Therefore, only the state closure requirements need to be analyzed for potential applicability or relevance and appropriateness to the remedial alternatives considered. No potential location-specific ARARs have been identified for this site.[2] Additionally, this example assumes that EPA and the State have agreed upon what non-ARAR information (i.e., guidance, advisories) is to be considered in designing the remedial alternatives.

Detailed Analysis - Case Example

Individual Analysis of Alternatives

The assembled remedial action alternatives represent a range of distinct waste management strategies which address the human health and environmental concerns associated with the site. Although the selected alternative will be further refined as necessary during the predesign phase, the description of the alternatives and the analysis with respect to the nine criteria presented below reflect the fundamental components of the various alternative hazardous waste management approaches being considered for this site.

The primary components of each alternative are listed in Figure F-2 and a technical description of these components is presented. After the technical description, a discussion of the alternative with respect to overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost follows.

The analysis of each alternative with respect to overall protection of human health and the environment provides a summary evaluation of how the alternative reduces the risk from potential exposure pathways through treatment, engineering, or institutional controls. This evaluation also examines whether alternatives pose any unacceptable short-term or cross-media impacts.

The major Federal and State requirements that are applicable or relevant and appropriate to each alternative are identified. The ability of each alternative to meet all of its respective ARARs or the need to justify a waiver is noted for each.

Long-term effectiveness and permanence are evaluated with respect to the magnitude of residual risk and the adequacy and reliability of controls used to manage remaining waste (untreated waste and treatment residuals) over the long-term. Alternatives that afford the highest degrees of long-term effectiveness and permanence are those that leave little or no waste remaining at the site such that long-term maintenance and monitoring are unnecessary and reliance on institutional controls is minimized.

The discussion on the reduction of toxicity, mobility, or volume through treatment addresses the anticipated performance of the treatment technologies a remedy may employ. This evaluation relates to the statutory preference for selecting a remedial action that employs treatment to reduce the toxicity, mobility, or volume of hazardous substances. Aspects of this criterion include the amount of waste treated or destroyed, the reduction in toxicity, mobility, or volume, the irreversibility of the treatment process, and the type and quantity of residuals resulting from any treatment process.

Evaluation of alternatives with respect to short-term effectiveness takes into account protection of workers and the community during the remedial action, environmental impacts from implementing the action, and the time required to achieve cleanup goals.

The analysis of implementability deals with the technical and administrative feasibility of implementing the alternatives as well as the availability of necessary goods and services. This criterion includes such items as: the ability to construct and operate components of the alternatives; the ability to obtain services, capacities, equipment, and specialists; the ability to monitor the performance and effectiveness of technologies; and the ability to obtain necessary approvals from other agencies.

The cost estimates presented in this report are order-of-magnitude level estimates. These costs are based on a variety of information including quotes from suppliers in the area of the site, generic unit costs, vendor information, conventional cost estimating guides, and prior experience. The feasibility study level cost estimates shown have been

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[2] Determinations of what standards/requirements are applicable or relevant and appropriate are made on a site-specific basis and, in some cases, on an alternative-specific basis. Therefore, the ARAR determinations in this example should not be construed necessarily as appropriate rationales for such determinations at other sites.

	Alternative				
	1	2	3	4	5
Ground Water	NO ACTION				
Monitoring		●	●	●	●
Natural Attenuation		●			
Extraction Wells			●	●	●
Onsite Air Stripping			●	●	●
Soil					
Soil/Clay Cap (Area 1)		●	●	●	●
Soil/Clay Cap (Area 2)		●			
Fixation (Area 1)				●	●
Soil Vapor Extraction (Area 2)			●	●	
Onsite Incineration (Area 2)					●
Others					
Institutional Controls		●	●	●	●
Road Reconstruction		●	●	●	●
Fence		●	●	●	●

Figure F-2. Alternative components case example.

prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The actual costs of the project will depend on true labor and material costs, actual site conditions, competitive market conditions, final project scope, the implementation schedule, and other variable factors. A significant uncertainty that would affect the cost is the actual volumes of contaminated soil and ground water. Most of these uncertainties would affect all of the costs presented in this FS similarly.

Capital costs include those expenditures required to implement a remedial action. Both direct and indirect costs are considered in the development of capital cost estimates. Direct costs include construction costs or expenditures for equipment, labor, and materials required to implement a remedial action. Indirect costs include those associated with engineering, permitting (as required), construction management, and other services necessary to carry out a remedial action.

Annual O&M costs, which include operation labor, maintenance materials, and labor, energy, and purchased services, have also been determined. The estimates include those O&M costs that may be incurred even after the initial remedial activity is complete. The present worth costs have been determined for 30 years at a 5 percent discount rate.

Alternative 1 – No Action

The no-action alternative provides a baseline for comparing other alternatives. Because no remedial activities would be implemented with the no-action alternative, long-term human health and environmental risks for the site essentially would be the same as those identified in the baseline risk assessment.

Criteria Assessment

Alternative 1 provides no control of exposure to the contaminated soil and no reduction in risk to human health posed through the ground water. It also allows for the possible continued migration of the contaminant plume and further degradation of the ground water.

Because no action is being taken, it would not meet any applicable or relevant and appropriate requirements such as the MCL for TCE.

This alternative includes no controls for exposure and no long-term management measures. All current and potential future risks would remain under this alternative.

This alternative provides no reduction in toxicity, mobility, or volume of the contaminated soil or ground water through treatment.

There would be no additional risks posed to the community, the workers, or the environment as a result of this alternative being implemented.

There are no implementability concerns posed by this remedy since no action would be taken.

The present worth cost and capital cost of Alternative 1 are estimated to be $0 since there would be no action.

Alternative 2-5: Common Components

All of the remaining alternatives have four components in common (use of institutional controls, reconstruction of access road, erection of a fence around the site, and ground water monitoring). Although the description of these components is not repeated in the discussions for each alternative, differences in their planned implementation are identified where appropriate.

- Institutional controls: The current owner has agreed to allow the state to place a deed restriction on the site which would prohibit soil excavation and construction of buildings on any part of the site still containing hazardous materials upon completion of the remedy.[3] In addition, a local ground water well regulation requiring state review of all installation plans for ground water wells would be used to prohibit the installation of drinking water supply wells in contaminated parts of the aquifer.
- Road reconstruction: Some of the road on the site (primarily near Area 2) would be restabilized and improved to allow construction activities and the movement of materials.
- Fencing: Approximately 1,600 feet of fencing would be installed around the perimeter of the site to restrict public access. Signs warning of the presence and potential danger of hazardous materials would be posted on the fence to further discourage unauthorized access to the site.
- Ground water monitoring: Two new monitoring wells would be installed offsite. Analytical results from the new wells, some of the existing wells, and the residential wells would be used to monitor future conditions and to assess the effectiveness of the final action. Sampling would be conducted quarterly with four replicate samples at each well. The samples would be analyzed for volatiles and metals and results compared to background values using the Student's T-test. If the mean value of any compound at any facility boundary well is greater than background at the 0.05 significance level in two successive sampling rounds, appropriate investigative and remedial action(s) would be initiated as necessary.

Alternative 2 – Cap and Natural Attenuation

The primary components of Alternative 2 are capping of Areas 1 and 2 and natural attenuation of the contaminated ground water. Two caps would be installed, a 3-acre cap over Area 1 (lead-contaminated soil) and a 3-acre cap over Area 2 (TCE-contaminated soil). The cap would be consistent with the State RCRA landfill closure requirements. While these requirements are not applicable since the action does not involve the disposal of any RCRA hazardous waste, certain closure requirements have nevertheless been determined to be relevant and appropriate to this alternative. The State's RCRA requirements are more specific and stringent than the Federal requirements, which require a cap to have a permeability less than or equal to the permeability of natural underlying soil. The soil/clay caps would include a 2-foot thick compacted clay barrier layer with a permeability not to exceed 10^{-7} cm/sec, a geonet drainage layer, and a cover layer equal to the average frost level (approximately 3.5 feet) above the barrier layer. This cover layer would include 6 inches of topsoil and 3 feet of compacted native soil materials. The drainage layer and the extra frost protection depth are necessary because the rainfall rate would exceed surface runoff and evaporation rates, and the average frost depth (3.5 feet) is greater than the minimum 2 feet of cover recommended by U.S. EPA.

A geonet drainage layer was chosen for this alternative since the Hydrologic Evaluation of Landfill Performance (HELP) model showed it to be more effective than sand in controlling leachate production but it is comparable in cost. The HELP model predicted a 75 to 80 percent reduction in leachate production. Geotextile layers would be laid on either side of the geonet drain to prevent clogging. A minimum slope of 3 percent would be provided to meet state requirements. To achieve this slope, it is estimated that 4,000 cy of backfill material from elsewhere on the site would have to be placed prior to cap construction.

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[3] The legal authority to implement deed restrictions will vary from state to state. Therefore, a key factor to consider during the evaluation of institutional controls is whether a particular state can actually impose restrictions on specific activities or whether their authorities are limited to nonenforceable actions such as deed notices.

To determine the effect of natural attenuation on the contaminated ground water, two assumptions about the subsurface have been made. First, despite the fractured nature of the bedrock, it has been assumed that the subsurface is homogeneous to facilitate the evaluation. Second, the potential for reduction in TCE concentrations has been assessed using a hydrogeologic model. The model took into account the fact that the cap would reduce existing leachate production by 75 percent. This model predicted that the concentration of TCE in the ground water would be reduced to a 1×10^{-4} excess cancer risk level (280 µg/l) at the edge of the contaminated soil areas within 35 years, a 1×10^{-5} excess cancer risk level (28 µg/l) in 60 years, and a 1×10^{-6} excess cancer risk level (2.8 µg/l, approximately equal to the MCL) in approximately 100 years.

An alternate water supply would be included in this alternative to provide a safe and reliable source of drinking water until levels in the aquifer reached acceptable levels. The alternate system would consist of two new community wells[4] installed upgradient of the contamination, 1,000 to 2,000 feet from the site and a water main along the county road to feeder pipes for each resident. The required pumping capacity is estimated to be 100 gpm and the wells would provide water for the four residents located closest to the site, downgradient of the contaminated plume. The well water would be monitored for TCE and lead as part of the site-wide monitoring plan on a semiannual basis until the MCL levels are met and then thereafter consistent with the relevant and appropriate aspects of the RCRA post-closure care program.

Criteria Assessment

Although protective of human health since exposure to all contamination would be controlled, Alternative 2 would allow continued migration of the existing contaminated ground water. It would prevent exposure to the contaminated soil and would minimize further release of contaminants to the ground water by limiting future infiltration through the cap.

This alternative would control exposure to the contaminated ground water through provision of an alternate supply of drinking water and deed restrictions until the MCL for TCE is eventually reached. The ground water may require up to 100 years of natural attenuation to reach the chemical-specific ARAR of 5 µg/l of TCE at the edge of the contaminated soil. Landfill closure requirements are not applicable to this alternative since the planned actions do not involve the disposal of any RCRA hazardous waste; however, certain landfill closure requirements have been determined to be relevant and appropriate. This alternative would meet the RCRA landfill closure requirements by constructing a soil/clay cap that meets the State RCRA standards, and the guidance specifications that the lead and support agencies have agreed are to be considered (TBC).

In order for this alternative to remain effective over the long-term, careful maintenance of the alternate water supply through monitoring and periodic repair of pipes and pumps and careful maintenance of a healthy vegetative layer over the caps would be required. Any erosional damage of the caps would have to be repaired. Failure to address reduction in the cap's impermeability could result in increased leachate production, subsequent ground water contamination, and the potential for direct contact with the contaminated soil. Because the contaminated soil would remain onsite and because the ground water may remain contaminated above health-based levels for 100 years, long-term monitoring, maintenance, and control would be required under this alternative. An alternate water supply and institutional controls would be used to limit risk to present and potential future users of the contaminated ground water. The institutional controls would only be effective with a high degree of certainty in the short term, not over the long term; once all design and construction activities are complete. The local municipality cannot ensure the enforceability of the local water use regulation beyond a few years. Because this alternative would leave hazardous substances onsite, a review would be conducted at least every 5 years to ensure that the remedy continues to provide adequate protection of human health and the environment in accordance with CERCLA 121(c).

This alternative would provide no reduction in the toxicity, mobility, or volume of the contaminated soil or ground water through treatment. The 20,000 cy of TCE-contaminated soil and 25,000 cy of lead-contaminated soil would remain onsite.

Within an estimated 6 months of beginning construction, the caps and the alternate water supply would be installed preventing direct exposure and reducing ground water contaminant migration. Provision of the alternate water supply would alleviate the risk from ingestion of contaminated ground water. The potential for a slight, temporary increase of risk to the community (and workers) due to particulate emissions during construction of the caps would be controlled through the use of dust control technologies (e.g., water or foam sprays).

No special techniques, materials, permits, or labor would be required to construct either the wells or caps. The native soil and clay are available locally, within 20 miles of the site. About 50,000 cy of soil and clay would be needed to construct the caps. The action could be enhanced by enlarging the caps if more contamination were discovered and by expanding the alternate water supply if more residents were affected than originally estimated.

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[4] The actual location of these wells would be determined during predesign activities.

The 30-year present worth cost of this alternative is estimated to be $4,800,000, with a capital cost of $4,200,000 and an annual O&M cost of $60,000. The capital cost is primarily for the installation of the caps. The annual O&M costs are primarily for the ground water monitoring program and for maintaining the caps.

Alternative 3 – In Situ Soil Vapor Extraction, Cap, Ground Water Pump and Treat

This alternative consists of capping Area 1 (lead-contaminated soil) with the same soil/clay cap as described in Alternative 2 (2 feet of clay underlying a surface drainage layer and 3.5 feet of soil), using in situ vapor extraction to treat the TCE-contaminated soil in Area 2, extracting the ground water, and treating it onsite through an air stripping system and discharging it to a tributary of North Creek.

The soil vapor extraction technology involves collection of soil vapor from the unsaturated zone by applying a vacuum at a series of extraction points. The vacuum not only draws vapor from the unsaturated zone, but also decreases the pressure around the soil particles, thereby releasing additional volatiles. In addition, due to the pressure differential, clean air from the atmosphere enters the soil to replace the extracted air.

Pilot tests conducted during the RI showed vapor extraction to be a feasible and effective technology for removing TCE from the soil at this site. It is anticipated that the TCE can be removed to 56 ppm which is the 1×10^{-6} risk level for the direct contact exposure route within 3 to 5 years. This represents a 99.9 percent reduction in the concentration. To provide flexibility of operation, the contaminated area would be divided into two discrete areas, each with its own vapor extraction system. The major components of each vapor extraction system would include: 20 extraction wells, the necessary piping and valves, and a positive displacement blower (vacuum pump). The air discharged would be sent through two activated carbon units and the carbon would be regenerated for reuse.

Because the evacuation and collection of volatiles would be through a vacuum system, volatile contaminants would be controlled as a single point emission. The potential for fugitive losses of air contaminants would be minimal.

A ground water extraction scenario consisting of five wells at a combined pumping rate of 300 gpm was selected after a series of numerical simulations with a variety of well arrangements. This arrangement was found to provide more rapid restoration of the shallow aquifer than other arrangements evaluated (see Chapter # of the FS). The three onsite extraction wells would be located within the TCE plume but downgradient of its center. They would reverse the natural ground water flow direction offsite immediately, so the contaminants would not migrate further than their existing location. The residential wells should not be contaminated in the future. Because it was determined that the pumping rate should not depress the ground water table more than 10 feet, not all of the plume could be captured by the onsite wells. Two offsite wells would be used to remediate the area of the offsite contaminated aquifer.

The ground water model simulation for this scenario assumed that the soil remedial action would include treatment of the TCE-contaminated soil to levels indicated above, and that the lead-contaminated soil would be capped. The simulation indicated that the shallow aquifer could be restored to 5 mg/l (MCL) in 25 to 40 years. Without soil remediation, from 60 to 100 years would be required. Monitoring would be used to determine when the ground water cleanup goal of 5 µg/l had been reached at the boundaries of the waste management area and to evaluate the effectiveness of the alternative.

To treat the extracted ground water, an air stripper would be constructed on the site. The air stripper would be a counter-current packed tower, where air enters at the bottom and exhausts at the top while the ground water flows down through the media. The air stripper would be approximately 45 feet tall and 4 feet in diameter and would be designed to meet the performance goal of 5 mg/l TCE concentrations. The exhaust air would be discharged through carbon beds to collect the volatiles by adsorption. The carbon would be sent offsite for regeneration upon bed exhaustion. Because little iron or other metals are in the ground water, no pretreatment to prevent fouling of the air stripper would be required.

Upon completion of ground water treatment, the water would be discharged offsite to the nearby tributary of North Creek. An NPDES permit would be obtained before implementation.

Criteria Assessment

This alternative would protect both human health and the environment. Soil vapor extraction and the cap over the contaminated soil would reduce risk to human health by direct contact and soil ingestion. Ground water extraction and onsite treatment would reduce the threat to human health by ingestion of contaminated ground water, and reduce the possibility of further environmental degradation.

This alternative would meet the MCL for TCE. To meet action-specific ARARs, the air treatment systems for this alternative would be designed to meet State air pollution control standards. Preliminary analysis also indicates that the ground water treatment system can be designed to meet State NPDES limitations which will result in no exceedances of the Water Quality Standards in the creek. Because the treatment of the TCE-contaminated soil would be conducted entirely in situ and the TCE is not a listed, RCRA hazardous waste, placement of RCRA hazardous waste would not occur and the land disposal restrictions would not be applicable nor relevant and appropriate. The cap constructed over Area 1 would meet the State RCRA requirements for landfill closure as under Alternative 2.

To provide for long-term effectiveness of this alternative, careful maintenance of the controls would be needed. As discussed for Alternative 2, the alternate water supply and cap would require maintenance. Further ground water contamination is reduced by removal of TCE through soil vapor extraction. Because lead is not expected to migrate rapidly, failure of the cap would increase the potential risk through direct contact but pose little or no concern for further ground water contamination. Human health risks posed by ingestion of ground water in the future would be reduced to less than 5 µg/l by the pump and treat systems. However, because of the fractured nature of the bedrock, the ability of the pump and treat system to effectively reach the cleanup goal is somewhat uncertain. To determine its long-term effectiveness and to lessen the uncertainty of reaching cleanup goals, the ground water pump and treat systems would be monitored under a long-term program. Necessary modifications to either system would be made based on monitoring results. The area treated by soil vapor extraction would not require any additional maintenance or monitoring upon completion of the technology. This alternative also would require a 5-year review.

Vapor extraction is an irreversible treatment process that would reduce the toxicity of contaminated soil by removing over 99.9 percent of TCE from 20,000 cy of soil. The TCE would be collected on carbon.[5] The air stripper would also reduce the toxicity and mobility of TCE in the ground water. Contaminants in the air stream would be collected on carbon and destroyed during regeneration making this ground water treatment component irreversible. This alternative would leave 25,000 cy of untreated lead-contaminated soil onsite under a soil/clay cap. This alternative meets the statutory preference for using treatment as a principal element since the principal threats are addressed through treatment.

During operation of the vapor extraction system, the contaminated soil would remain uncovered, although the fence to be installed around the site would discourage trespassers and limit potential exposure. Although unlikely, the possibility of a small additional risk through inhalation to the community would exist if the extracted air collection system were to fail. As with the soil vapor extraction system, there is the slight additional risk of failure of the air collection system on the air stripper. Safety techniques including monitoring the equipment would be used to minimize any failures of the components. Once the extraction and treatment systems are installed, the contaminant plume would begin to recede from its current position. Between 25 and 40 years would be required to reach ground water remediation goals, and 3 to 5 years of soil vapor extraction would be required to reach soil remediation goals.

This alternative involves the use of proven technologies. The cap requires 25,000 cy of soil and clay to be brought to the site, placed, and graded to construct the cap. The onsite air stripper and both gaseous carbon adsorption systems require available equipment. Operation of the alternative would require frequent monitoring of the ground water and the air to assess the effectiveness of the soil vapor extraction and ground water extraction and treatment systems. Controlling operating conditions would be necessary to improve the effectiveness of these systems. Soil vapor extraction uses reliable equipment. Engineering judgment would be required during operation to determine the operating parameters of the alternative, such as air flow rate in the air stripper, the blower speed in the vapor extraction system, and TCE in the exhaust gas. All of the components could be expanded if additional contamination were discovered. The 30-year present worth cost is estimated to be $7,300,000 with a projected $3,300,000 for capital expenditures and $440,000 for year 1 annual O&M costs. The most expensive item is the soil/clay cap followed by the ground water treatment system. The O&M costs would cover operating the soil and ground water treatment systems from year 1 to 5. After year 5 the O&M costs would drop to approximately $200,000 to continue ground water treatment and monitoring.

Alternative 4 – In Situ Soil Vapor Extraction, In Situ Soil Fixation, Cap, and Ground Water Pump and Treat

This alternative includes in situ soil vapor extraction of TCE-contaminated soil (Area 2), in situ soil fixation of lead-contaminated soil (Area 1), cap (Area 1), and ground water pump and treat components of Alternative 3.

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[5] TCE would be destroyed by incineration when the carbon is regenerated.

The moisture content of the soil has been determined to be approximately 50 percent under worst case conditions. Using this information and results from vendor tests, it has been determined that a minimum dose of one part solidification reagent to two parts soil is required for migration control of lead. Testing has shown that the optimum solidification reagent mixture would consist of approximately 50 percent fly ash and 50 percent kiln dust. Thus, approximately 7,000 tons each of fly ash and cement kiln dust would be required. The reagents would be added in situ with a backhoe. As one area of the soil is fixed, the equipment could be moved onto the fixed soil to blend the next section. It is anticipated that the soil volume would expand approximately 20 percent due to the fixation process. This additional volume would be used to achieve the needed slope for the cap. An RCRA soil/clay cap placed over the solidified material is necessary to prevent infiltration and additional hydraulic stress on the fixed soil. It is estimated that the fixation would reduce lead migration by 40 percent and that the fixed soil would pass the EPTox levels for lead.

Criteria Assessment

This alternative would protect human health and the environment. This alternative protects against direct contact with contaminated soil and further ground water degradation by treating part of the soil and fixing and capping the remaining soil. It protects against ingestion of contaminated ground water by collecting and treating the affected aquifer to health-based levels.

This alternative meets the MCL for TCE and action-specific ARARs such as air and water discharge limits. As with Alternative 3, the land disposal restrictions are not an ARAR for this alternative since placement does not occur. The cap would meet State RCRA requirements for landfill closure.

The long-term effectiveness of this alternative would be enhanced by the application of treatment technologies that reduce the inherent hazards posed by the sources; all of the contaminated soil would be treated or immobilized by fixation and the contaminated ground water would also be extracted and treated. Even in the unlikely event of cap failure in Area 1, the fixed soil would pose little if any risk of ground water contamination. The potential for cap failure would be minimized through the maintenance program. This alternative would also require a 5-year review.

Soil vapor extraction and air stripping with gaseous carbon adsorption are irreversible. Soil fixation would reduce the mobility of lead by about 40 percent but would increase the volume of contaminated soil from 25,000 cy to about 30,000 cy. Although this technology is not completely irreversible, the possibility exists that the contaminants could regain some mobility should the cap fail. However, the risk would be small. The residual soil remaining following treatment would not pose a risk to human health or the environment. This alternative satisfies the statutory preference for using treatment as a principal element since it addresses principal threats posed by the site through treatment.

During the vapor extraction process, the contaminated soil would be uncovered and the potential exists for contaminant release into the air (although the risk would be small due to the control system that would be used). In situ soil fixation would release some particulate matter into the atmosphere. However, the fixation process would require only a few months for implementation, lessening the likelihood of any potential risk. Dust control methods would be used to limit the release of particulate matter.

Implementability information for the soil vapor extraction system, the cap, and the ground water pump and treat systems to be used for this evaluation, is provided under Alternative 3. As for the additional fixation process, vendors needed to fix the soil are readily available. The necessary reagents are available within 50 miles of the site. All of the components could be expanded if additional contamination was discovered.

The 30-year present worth cost of this alternative is estimated to be $10,200,000. The primary cost items are the cap, the ground water treatment system, and the soil fixation of Area 2. The capital cost is estimated to be $6,200,000, with an annual O&M cost of $480,000 for the first 5 years. After year 5, the O&M costs would decrease to $200,000 for ground water treatment and monitoring.

Alternative 5 – Incineration, In Situ Soil Fixation, Ground Water Pump and Treat

This alternative contains components of Alternatives 3 and 4 but introduces a thermal destruction component to address the TCE-contaminated soil. The lead-contaminated soil in Area 1 would be fixed and covered with a soil/clay cap, as described in Alternative 4. The ground water would be addressed through pumping and treating, via an air stripper, as described in Alternatives 3 and 4. The TCE-contaminated soil in Area 2 would be excavated and treated onsite by a thermal destruction unit.

For the purposes of this analysis, the thermal destruction unit is assumed to be a rotary kiln unit. The specific type of incineration would be determined in the Remedial Design phase after competitive bidding has taken place. The incinerator would be mobilized, operated, and closed according to the specific requirements found in RCRA, Subpart O (40 CFR 264.340). The substantive requirements of the permitting process, though not applicable because the action does not involve RCRA-regulated hazardous waste, have been determined to be relevant and appropriate. A discussion of the ARARs associated with the remediation of Area 1 and the ground water can be found under Alternative 4.

It is estimated that approximately 20,000 cy of contaminated soil would need to be excavated and treated. The risk from the remaining soil would not exceed 1 × 10^{-6} excess cancer risk level as soil containing TCE at concentrations greater than 56 ppm would be excavated. There are still some uncertainties with this volume estimate so it would be necessary to sample during excavation to determine when sufficient material has been removed.

Incineration of soils contaminated with organic compounds is a proven technology. Conservative estimates about the organic and moisture contents were made to develop the incineration component. The incinerator would be operated continuously (24 hours/day, 365 days/year) in order to reduce the thermal stress on the refractory, although some down time would be required (20 percent) for regular maintenance. Due to the need to maintain continuous operation, a waste pile for the purpose of temporary storage would be constructed in accordance with the relevant and appropriate requirements of RCRA (40 CFR 264.251) which requires a liner and leachate collection system. This storage would ensure operation during periods of poor weather when excavation may not be possible.

The incinerator would operate at a feed rate of 3.5 tons/hr. At this feed rate and assuming that about 20,000 cy of material would be excavated, more than 1 year would be required for incineration. About 30 gallons/hr of fuel oil would be required to run the incinerator. It is assumed that the incinerator would be operated to achieve 99.8 percent TCE removal from the soil and a destruction efficiency as required by RCRA. Specific operating practices to meet the performance objectives, including 99.99 percent destruction of stack emissions as dictated by Subpart O of RCRA, would be determined through a trial burn at the site after installation of the incinerator. Other performance standards include hydrogen chloride emissions not to exceed 1.8 kg/hr and particulate matter emissions of less than 0.08 grains per day standard cubic foot.

The facility would use a dry scrubber system for emission control, which would almost eliminate the need for wastewater treatment. Any water from emission control and from decontamination procedures would be treated in the onsite ground water treatment system. The residual soil and collected ash is assumed to be nonhazardous and can be disposed of in a solid waste disposal facility in compliance with Subtitle D of RCRA. In the event that they cannot be delisted due to the presence of metals, either residuals will be managed as part of the closure of Area 2 (lead-contaminated soil).

Criteria Assessment

This alternative would be protective of human health and the environment. The contaminated ground water would be collected and treated, reducing further the threat of ingesting contaminated ground water. The risk from ingesting ground water would be lowered to less than 1 × 10^{-6}. The direct contact risk would be reduced by fixing soil exceeding 200 µg/kg lead and incinerating TCE-contaminated soil with an excess cancer risk level greater than 1 × 10^{-6}.

Although this alternative would involve the excavation and placement of waste, thus making the land disposal restrictions a potential ARAR, TCE-contaminated soil at this site is not an RCRA hazardous waste and therefore these requirements would not be applicable. The U.S. EPA is undertaking an LDR rulemaking that will specifically apply to soil and debris. Until that rulemaking is completed, the CERCLA program will not consider the land disposal restrictions to be relevant and appropriate to soil and debris that does not contain RCRA-restricted wastes.

The long-term effectiveness of this alternative is enhanced by the destruction of about half of the contaminated soil by thermal destruction and reduction in the mobility of contaminants in the other half through fixation. The ground water pump and treat component is also effective but would require long-term management or monitoring and maintenance. The area where soil is removed for incineration would not require long-term monitoring whereas the contaminated soil that is fixed would remain under a cap and would require long-term monitoring and maintenance. This alternative could be enhanced to effectively control greater areas of contamination or different contaminants (i.e., possible metals in Area 2). Because the fixed soil will remain onsite, this alternative would require a 5-year review.

This alternative reduces the toxicity, mobility, and volume of soil contaminants by incineration. Incineration would destroy an estimated 99.8 percent of the hazardous constituents present in the soil of Area 2, based on previous experience with this technology at other sites. Approximately 18,000 cy of treated soil that would pose minimal risk to human health or the environment would be disposed offsite in the local municipal landfill. Approximately 30,000 cy of soil in Area 1 would remain although the mobility of the lead would be reduced by approximately 40 percent through fixation. Virtually no risk from this soil would exist as long as the cap is properly maintained to control exposure. Ninety-six percent of the contaminants in the ground water would be removed and eventually destroyed as discussed under Alternatives 3 and 4. This alternative meets the statutory preference for using treatment as a principal element since it addresses the principal threats posed by the site through treatment.

Fixation would require approximately 6 months to complete and would potentially release particulate matter into the air. Excavation and incineration would require approximately a year and may release volatiles into the air. The minor risks from both situations to both workers and the community would be temporary. Air monitoring and foam covers would be used to further minimize the likelihood of risk. The additional risk to workers through operating an incinerator (because of the complexity of the equipment and the high operational temperatures) would be mitigated through the proper use of safety protocols, proper drainage controls, and restrictions on access to contaminated areas. Although emissions from the incinerator would comply with all air quality regulations, potential accidental releases could temporarily affect air quality in the vicinity of the site.

This alternative is inherently difficult to implement due to the incineration component. Operation of an incinerator is mechanically complex and has stringent monitoring requirements to provide proper performance. Consequently, the incinerator and associated facilities require highly trained staff and a substantial amount of attention. In addition, it may be necessary to postpone the implementation until an available mobile incinerator can be found. If metal concentrations in the soil are very high, incineration would not be used and the soil would be fixed along with the soil in Area 1.

It has been estimated that the present worth cost for this alternative would be $15,000,000, primarily because of the incineration component. The capital cost would be $13,000,000 and the first year annual O&M is estimated at $1,200,000 with most of the cost as a result of operating the incinerator. Subsequent year O&M costs would be about $200,000 since only the ground water treatment and monitoring systems would be operating.

Table F-1 summarizes the above discussion.

Comparative Analysis

In the following analysis, the alternatives are evaluated in relation to one another for each of the evaluation criteria.[6] The purpose of this analysis is to identify the relative advantages and disadvantages of each alternative.

Overall Protection of Human Health and the Environment

All of the alternatives, except Alternative 1 (no action), provide adequate protection of human health and the environment. Risk through direct contact and ground water ingestion are reduced to cancer risk levels less than 1×10^{-6} through each pathway. Alternatives 3, 4, and 5 prevent further migration of the contaminated ground water by extracting and treating the plume to health-based ARAR levels.

Alternative 2 achieves protection by preventing exposure through capping and natural attenuation of the contaminated ground water. Alternative 3 combines treatment to reduce the risk from the TCE-contaminated soil and ground water and capping of the lead area. Alternatives 4 and 5 reduce risks posed by all portions of the site through treatment.

There is some uncertainty about the potential presence of metals in the TCE-contaminated soil of Area 2. If metal concentrations of concern are present, only Alternatives 2 and 5 would protect against direct contact and further ground-water contamination through a cap and incineration, respectively. Incineration of metal-contaminated soil may result in a hazardous waste residue which would have to be disposed of in a hazardous waste landfill. Alternatives 3 and 4 rely on vapor extraction to remedy the soil in Area 2. Soil vapor extraction would not lower risks from metals to human health or the environment.

Compliance with ARARs

The evaluation of the ability of the alternatives to comply with ARARs included a review of chemical-specific and action-specific ARARs that was presented earlier in the report. There are no known location-specific ARARs for this site. All alternatives will meet all of their respective ARARs except the no-action alternative.

Long-Term Effectiveness and Permanence

Alternatives 4 and 5 afford the highest degrees of long-term effectiveness and permanence because both alternatives use treatment or fixation technologies to reduce hazards posed by all known wastes at the site. While some contaminated soil would remain after implementation of both alternatives, it would be fixed to reduce mobility. These two alternatives differ only in the technology used to treat the TCE-laden soil. Although incineration would destroy more TCE than soil vapor extraction, both alternatives reduce risks posed by the waste to a 1 × 10^{-6} cancer risk levels through both the ground water and soil pathways.

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[6] State and community acceptance will be addressed in the ROD following comments on the RI/FS report and the proposed plan.

Alternatives 4 and 5 would rely on a soil/clay cap to control infiltration, a reliable technology if properly maintained. In addition, Alternative 5 would also employ a solid waste landfill to manage the residue from incineration. Upon completion, some long-term maintenance of the cap and ground water monitoring would be required for both alternatives until the alternative has met the health-based cleanup goals for ground water, at which point the monitoring can be discontinued. These alternatives would have almost no long-term reliance on institutional controls.

Alternative 3 eliminates the risk of exposure at the site to the same levels as Alternatives 4 and 5 in the short-term; however, it relies solely upon a cap for controlling the waste remaining in Area 1. Although capping is an effective and accepted approach for reducing risk from direct contact with wastes, it is less reliable in the long-term than treatment to remove or fix contaminants in soil since the inherent hazard of the lead would remain. Since a potential for cap failure, however small, would exist, the long-term effectiveness of Alternative 3 would not be as reliable as Alternatives 4 and 5. Long-term management requirements for Alternative 3 are similar as those of Alternative 4 or 5; operation of the ground water pump and treat systems would be required for 25 to 40 years. However, the capped area under Alternative 3 is greater in size than the capped areas under Alternatives 4 and 5.

Alternative 2 leaves all of the contaminated waste at the site and relies solely upon a cap and institutional controls to prevent exposure. Although the alternate water supply lowers the risk of ingesting contaminated ground water from existing wells, the local municipality estimates that the existing regulations to be used as institutional controls would not be effective with a high degree of certainty for more than 5 to 10 years in preventing the installation of new wells and the ingestion of contaminated ground water.

Alternative 2 also has long-term ground water monitoring and cap maintenance requirements (mowing, revegetation, cap repair) which are more critical for the effectiveness of this alternative since all of the waste (without any type of treatment to reduce their mobility, toxicity, or volume) remains at the site under the caps. Failure to detect a problem with the cap may result in direct contact with the contaminated soil and further degradation of the ground water through leachate production. Monitoring will continue until the health-based cleanup goals are met. A 5-year review would be necessary to verify that the remedy remains protective.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 4 and 5 use treatment or fixation technologies to reduce the inherent hazards posed by all known waste at the site. Both of these alternatives would either treat, fix, or excavate and incinerate all soil posing more than a 1 × 10^{-6} excess cancer risk level by ingestion. Both alternatives treat the ground water and then treat the contaminated air stream from the air stripper with GAC. Regeneration of the GAC ultimately destroys the TCE. The soil vapor extraction system also contains GAC gaseous treatment. Both alternatives also fix the soil contaminated with lead, reducing the mobility of the lead by an estimated 40 percent. Neither alternative completely treats all of the soil at the site. Both alternatives produce 30,000 cy of fixed soil, and 18,000 to 20,000 cy of treated soil. Under Alternative 5, 18,000 cy of soil (with 99.8 percent of the TCE destroyed) would remain. Under Alternative 4, 20,000 cy of soil (with 99.9 percent of the TCE removed and ultimately destroyed) would remain. These two alternatives would satisfy the statutory preference for treatment as a principal element.

Alternative 3 treats the principal threats posed by the soil and the ground water and thus also satisfies the statutory preference for treatment as a principal element. Approximately 25,000 cy of lead-contaminated soil would remain untreated onsite. However, the mobility of this lead is very low. Alternative 3 reduces the toxicity of 20,000 cy of TCE-contaminated soil by using soil vapor extraction at Area 1. Alternative 3 also reduces the volume and toxicity of contaminated ground water.

Alternative 2 uses no treatment technologies. All of the contaminated soil, controlled by a cap, and all of the contaminated ground water would remain, although the contaminants in the groundwater will naturally attenuate.

Short-Term Effectiveness

Alternative 2 is anticipated to have the greatest short-term effectiveness. Alternative 2 presents the least amount of risk to workers, the community, and the environment. Some particulate emissions from cap installation is anticipated during implementation; however, dust control methods should reduce this risk. The other alternatives could release volatiles during excavation activities or soil vapor extraction. These emissions may be more difficult to control.

The time required to achieve short-term protection would be shorter than for any other alternative. It is anticipated that only 6 months would be required to

Table F-1
INDIVIDUAL EVALUATION OF FINAL ALTERNATIVES
CASE STUDY

Criteria	Alternative 1 No Action	Alternative 2 Cap, Natural Attenuation	Alternative 3 In-situ Soil Vapor Extraction, Cap, Ground-water Pump and Treat	Alternative 4 In-situ Soil Vapor Extraction, In-situ Soil Fixation, Cap, Ground-water Pump and Treat	Alternative 5 In-situ Soil Fixation, Cap, Incineration, Ground-water Pump and Treat
OVERALL PROTECTIVENESS					
Human Health Protection					
- Direct Contact/ Soil Ingestion	No significant reduction in risk. Some reduction in access to risk through fence.	Cap reduces direct contact risk and soil ingestion risk to less than 1 x 10^{-6}.	Cap and vapor extraction reduce direct contact/ soil ingestion risk to less than 1 x 10^{-6}.	Cap, fixation, vapor extraction reduce direct contact/soil ingestion risk to less than 1 x 10^{-6}.	Cap, fixation, incineration reduce direct contact/soil ingestion risk to less than 1 x 10^{-6}.
- Ground-water Ingestion for Existing Users	No reduction in risk.	Protects against existing risk by providing an alternate water supply.	Reduces risk to less than 1 x 10^{-6} by pump and treat.	See Alternative 3.	See Alternative 3.
- Ground-water Ingestion for Future Users	No reduction in risk.	Institutional controls provide protection against risk from ground-water ingestion.	Reduces risk to less than 1 x 10^{-6} by pump and treat.	See Alternative 3.	See Alternative 3.
Environmental Protection	Allows continued contamination of the ground water.	Continued contamination is curtailed by use of cap. Continued migration of contaminated groundwater is allowed.	Continued contamination is curtailed by soil vapor extraction and by cap. Migration of contaminated ground water is curtailed by pump and treat.	Continued contamination is curtailed by soil vapor extraction, soil fixation, and cap. Migration of contaminated ground water is curtailed by pump and treat.	Continued contamination is curtailed by soil fixation and incineration. Migration of contaminated groundwater is curtailed by pump and treat.
COMPLIANCE WITH ARARs					
Chemical-Specific ARARs	Does not meet ground-water standards past the site boundary.	Would meet MCLs at the waste boundary in over 50 years.	Would meet MCLs at the waste boundary in 25-40 years.	See Alternative 3.	See Alternative 3.
Location-Specific ARARs	Not relevant. There are no location-specific ARARs.	See Alternative 1.	See Alternative 1.	See Alternative 1.	See Alternative 1.
Action-Specific ARARs	Would not meet any ARARs since there will be no action.	Will meet RCRA landfill closure requirements.	Would meet RCRA landfill closure requirements. Would also meet air release standards from the vapor extraction system. Would meet NPDES requirements.	Would meet air release standards from air strippers and vapor extraction system. Would meet NPDES requirements. Would meet RCRA landfill closure requirements.	Would meet regulations concerning incineration and air stripping. Would meet NPDES requirements. Would meet RCRA landfill closure requirements.
Other Criteria and Guidance	Would allow ingestion of ground water exceeding 1 x 10^{-4}. Would not protect against Pb levels above 200 mg/kg in soil.	Protects against soil ingestion to 1 x 10^{-6} level and ground-water ingestion at 1 x 10^{-6} level. Covers soil with Pb above 200 mg/kg.	See Alternative 2.	See Alternative 2.	See Alternative 2.

Table F-1 (Continued)

Criteria	Alternative 1 No Action	Alternative 2 Cap, Natural Attenuation	Alternative 3 In-situ Soil Vapor Extraction, Cap, Groundwater Pump and Treat	Alternative 4 In-situ Soil Vapor Extraction, In-situ Soil Fixation, Cap, Groundwater Pump and Treat	Alternative 5 In-situ Soil Fixation, Cap, Incineration, Groundwater Pump and Treat
LONG-TERM EFFECTIVENESS AND PERMANENCE					
Magnitude of Residual Risk					
- Direct Contact/ Soil Ingestion	Source has not been removed. Existing risk will remain.	Risk eliminated as long as cap is maintained. Because source is only contained, inherent hazard of waste remains.	Risk eliminated through vapor extraction and cap. Some inherent hazard remains in the lead material under the cap. Risk from lead would only occur if the cap were destroyed.	Slight chance of future risk from fixed lead-contaminated soil.	See Alternative 4.
- Ground-water Ingestion for Existing Users	Future risk greater as plume migrates to residents. Eventually natural attenuation and dilution may decrease risk. Risk significant for about 100 years.	Risk eliminated by providing alternate water supply. Some risk would remain for over 100 years if the ground water is used.	Risk eliminated by extracting ground water exceeding 10^{-6} cancer risk levels. Safe drinking water achieved in 25-40 years with source control.	See Alternative 3.	See Alternative 3.
- Ground-water Ingestion for Future Users	Risk greater as area of contamination increases. Eventually natural attenuation and dilution may decrease risk. Risk significant for about 100 years.	Institutional controls used to control use of contaminated ground water. Unauthorized use of ground water would result in increased risk.	Risk eliminated by extracting ground water exceeding 10^{-6} cancer risk levels. Safe drinking water achieved in 25-40 years with source control.	See Alternative 3.	See Alternative 3.
Adequacy and Reliability of Controls	No controls over remaining contamination. No reliability.	Risk to ground water controlled by alternate water supply and institutional controls. Soil/clay cap controls contaminated soil. Cap effective for Area 2 even if metals are present. Institutional controls are limited in effectiveness.	Soil/clay cap controls remaining contaminated soil in Area 1. Would need additional controls for Area 2 if metals are present since soil vapor extraction would not remove metals. Groundwater extraction controls contaminated groundwater. Both are adequate.	See Alternative 3.	Similar to Alternative 3. Incinerator ash disposed in municipal landfill. If metals are present in Area 2, incinerator ash would be disposed in RCRA landfill.
		Reliability of cap can be high if maintained. Institutional controls to control use of ground water not very reliable.	Reliability of vapor extraction high because no long-term O&M is required. Cap reliable if maintained. Groundwater pump and treat is reliable.	Reliability of fixation with cap high, as are vapor extraction and ground-water pump and treat.	Incineration very reliable because material is destroyed. Fixation with cap and groundwater pump and treat are reliable.
Need for 5-Year Review	Review would be required to ensure adequate protection of human health and the environment is maintained.	See Alternative 1. TCE and lead soil would remain onsite.	See Alternative 1. Lead-contaminated soil would remain onsite.	See Alternative 1. Fixed lead residuals would remain onsite.	See Alternative 1. Fixed lead residuals would remain onsite.

Table F-1 (Continued)

Criteria	Alternative 1 No Action	Alternative 2 Cap, Natural Attenuation	Alternative 3 In-situ Soil Vapor Extraction, Cap, Groundwater Pump and Treat	Alternative 4 In-situ Soil Vapor Extraction, In-situ Soil Fixation, Cap, Groundwater Pump and Treat	Alternative 5 In-situ Soil Fixation, Cap, Incineration, Groundwater Pump and Treat
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT					
Treatment Process Used	None.	None.	Vapor extraction of soil and groundwater air stripping.	Vapor extraction, soil fixation, and groundwater air stripping.	Incineration, soil fixation, and groundwater air stripping.
Amount Destroyed or Treated	None.	None.	99.9% of volatiles in soil and 96% volatiles in groundwater removed and destroyed by carbon regeneration.	Same as Alternative 3 plus 25,000 cy of contaminated soil is fixed.	99.8% of volatiles in 20,000 cy of soil destroyed and 25,000 cy of contaminated soil is fixed.
Reduction of Toxicity, Mobility, or Volume	None.	None.	Reduced volume and toxicity of contaminated groundwater. Toxicity of soil contamination reduced.	Reduced volume and toxicity of contaminated groundwater. Toxicity of soil contamination in Area 2 reduced 97%. Mobility of contaminants in Area 1 reduced 10% while volume increased 20%.	Incineration reduces volume of contaminated soil by 20,000 cy and reduces toxicity. Mobility of contaminants in Area 1 is reduced. Volume and toxicity of contaminated ground water is reduced.
Irreversible Treatment	None.	None.	Vapor extraction and air stripping are irreversible with regeneration of carbon used for air stream treatment.	See Alternative 3.	Incineration is irreversible. Air stripping with subsequent gaseous carbon treatment and regeneration is irreversible.
Type and Quantity of Residuals Remaining After Treatment	No residuals remain.	None.	No detectable residuals in Area 2 remain. Carbon from gaseous treatment requires regeneration.	No detectable residuals in Area 2 remain. 30,000 cy of fixed soils remain in Area 1.	Incinerated soil (18,000 cy) and fixed soils (30,000 cy) remain. Incinerated soil expected to be nonhazardous. Carbon from gaseous treatment remains, requiring regeneration.
Statutory Preference For Treatment	Does not satisfy.	Does not satisfy.	Satisfies.	Satisfies.	Satisfies.
SHORT-TERM EFFECTIVENESS					
Community Protection	Risk to community not increased by remedy implementation, but, contaminated water may reach the residents within 1-3 years.	Temporary increase in dust production through cap installation. Contaminated soils remain undisturbed.	Soil would remain uncovered during vapor extraction for 3-5 years. Temporary increase in dust production during cap installation.	Similar to Alternative 3. Fixation may result in dust and odor increase.	Soil would remain uncovered during incineration (about 1 year). Excavation and fixation would release dust and odors to the atmosphere.
Worker Protection	No significant risk to workers.	Protection required against dermal contact and inhalation of contaminated dust during cap construction.	Protection required against dermal contact, vapor or dust inhalation during construction and operation of vapor extraction system and air stripper.	Protection required against dermal contact, vapor, or dust inhalation during construction and operation of vapor extraction system, fixation, and air stripper.	Protection required against dermal contact and inhalation of volatiles and particulates as a result of excavation, fixing, and incinerating TCE soil.

Table F-1 (Continued)

Criteria	Alternative 1 No Action	Alternative 2 Cap, Natural Attenuation	Alternative 3 In-situ Soil Vapor Extraction, Cap, Ground-water Pump and Treat	Alternative 4 In-situ Soil Vapor Extraction, In-situ Soil Fixation, Cap, Ground-water Pump and Treat	Alternative 5 In-situ Soil Fixation, Cap, Incineration, Ground-water Pump and Treat
SHORT-TERM EFFECTIVENESS (Cont'd)					
Environmental Impacts	Continued impact from existing conditions.	Would be some migration of contaminant plume as part of attenuation process.	Vapor extraction may impact air quality and odors although it will meet emission standards. Would be aquifer draw-down during ground-water extraction.	See Alternative 3. Fixation may also affect air quality and produce odors.	Incineration may impact air quality, produce odors, although it will meet emission standards.
Time Until Action is Complete	Not applicable	Cap installed in 6 months. Risk from ground water reduced within 3 months due to alternate water supply and institutional controls.	Soil vapor extraction complete in 3-5 years. Capping complete in 6 months. Ground-water remedial action complete in 25-40 years.	Fixation and capping completed in 9 months. Soil vapor extraction complete in 3-5 years. Ground-water action complete in 25-40 years.	Incineration complete in 2 years from design completion. Fixation and capping complete in 9 months. Groundwater action complete in 25-40 years.
IMPLEMENTABILITY					
Ability to Construct and Operate	No construction or operation.	Simple to operate and construct. Would require materials handling of about 50,000 cy of soil and clay.	Vapor extraction requires some operation. Fairly straightforward to construct. Cap construction would require materials handling of 75,000 cy of soil and clay. Onsite ground-water treatment requires operation.	Fixation with cap somewhat difficult to construct. Otherwise similar to Alternative 3.	Incineration is difficult to operate. Fixation with cap is somewhat difficult to construct. Similar to Alternative 3 with respect to ground water.
Ease of Doing More Action if Needed	If monitoring indicates more action is necessary, may need to go through the FS/ROD process again.	Simple to extend extraction system and cap. Cap would be sufficient if metals were significant in Area 2. Could implement ground-water treatment if necessary.	Simple to extend ground-water extraction system, vapor extraction system, and cap. However, if significant metal concentrations are present in Area 2, may need additional soil treatment or would need to extend cap.	Fairly complete alternative. Can increase volume of or modify all technologies. If significant metal concentrations are present in Area 2, could use fixation.	Complete alternative. Can handle varying volumes or concentrations.
Ability to Monitor Effectiveness	No monitoring. Failure to detect contamination means ingestion of contaminated ground water.	Proposed monitoring will give notice of failure before significant exposure occurs.	See Alternative 2.	See Alternative 2.	See Alternative 2.

Table F-1 (Continued)

Criteria	Alternative 1 No Action	Alternative 2 Cap, Natural Attenuation	Alternative 3 In-situ Soil Vapor Extraction, Cap, Groundwater Pump and Treat	Alternative 4 In-situ Soil Vapor Extraction, In-situ Soil Fixation, Cap, Groundwater Pump and Treat	Alternative 5 In-situ Soil Fixation, Cap, Incineration, Groundwater Pump and Treat
IMPLEMENTABILITY (Cont'd)					
Ability to Obtain Approvals and Coordinate with Other Agencies	No approval necessary.	See Alternative 1.	Need an NPDES permit. Should be easy to obtain.	See Alternative 3.	Need to demonstrate technical intent of incinerator permit. Need an NPDES permit.
Availability of Services and Capacities	No services or capacities required.	See Alternative 1.	See Alternative 1.	Need fixation services.	Need fixation and incineration services.
Availability of Equipment, Specialists, and Materials	None required.	No special equipment, material, or specialists required. Cap materials available within 20 miles.	Needs readily available specialists to install and monitor vapor extraction system. Need treatment plant operators. Cap materials available within 20 miles.	See Alternative 3.	Need a mobile incinerator and trained operators. Need treatment plant operators. Closest source of incinerator is 500 miles from site.
Availability of Technologies	None required.	Cap technology readily available.	Vapor extraction well developed. Will require pilot testing.	Vapor extraction and fixation well developed. Will require pilot testing.	Incineration and fixation well developed. Will require pilot testing.
COST					
Capital Cost	$ 0	$ 4,200,000	$ 3,300,000	$ 6,200,000	$13,000,000
First Year Annual O&M Cost	0	60,000	440,000	480,000	1,200,000
Present Worth Cost	0	4,800,000	7,300,000	10,200,000	16,000,000

install a new cap and to provide an alternate water supply. Alternatives 3 and 4, involving vapor extraction require 3 to 5 years before the risk from direct soil contact and ingestion is controlled.

Alternatives 3 and 4 are very similar with respect to short-term effectiveness. Implementing the soil vapor extraction system requires the most time of the source control actions. There is a small potential for risk to the community, workers, and the environment through volatile emissions during extraction to the air in the unlikely event of control failure.

Alternative 5 would take longer to implement than Alternative 2 and has a greater potential of releasing volatiles to the atmosphere during excavation than Alternatives 3 and 4. However, implementation of Alternative 5 would take less time than Alternatives 3 and 4 since incineration would require less time than soil vapor extraction to remediate the soil to safe levels. However there may be a possibility of volatile emissions during excavation that would need to be controlled. Alternative 5 has the disadvantage of requiring incineration equipment (the most technically complex equipment of any of the alternatives) which could increase the risk to workers in the event of a failure. Careful implementation of standard safety protocols would lessen this risk.

Implementability

Alternative 2 would be the simplest to construct and operate. While construction of a cap would have significant materials handling requirements, the materials are available locally. Expansion of the cap could incorporate other areas of contamination if discovered during activities at the site, specifically if metals become an issue at Area 2. Periodic maintenance of the cap should control its reliability in the future. The ground water monitoring program would determine the effectiveness of the cap at decreasing future contamination of the ground water. The alternate water supply would reliably supply safe drinking water despite the fractured nature of the aquifer.

Construction requirements for Alternative 3 are fairly simple. Alternative 3 has more operational requirements than Alternatives 1 and 2 because of the soil vapor extraction system and the air stripper. As with the other alternatives, if additional contamination is found at the site, the components could be sized to include the additional areas. However, if metals were found in Area 2, soil vapor extraction would not effectively treat the soil and another technology would need to be used to control the risk from direct contact.

Soil vapor extraction is a fairly reliable technology because of its mechanical simplicity. Very little downtime is anticipated. However, as with any in situ treatment system, samples throughout the soil (both varying in location and in depth) must be taken frequently to determine the effectiveness of the technology.

Alternative 3 would require readily available engineering services and cap materials. An air stripper could readily be obtained and constructed onsite. All of the treatment technologies proposed for this alternative are proven. However, it would be difficult to evaluate the effectiveness of the ground water extraction system in the fractured aquifer. It would be difficult to determine where to install extraction wells to intercept contamination since the fractures would be difficult to locate. Additional treatability studies for the soil treatment component of this alternative and some fracture trace analysis would help ensure the success of this alternative.

Alternative 4 is more complex than Alternative 3 because of the in situ soil fixation component. While this component has no additional operation requirements, it would require additional construction techniques that would have to be supplied by specialists in this area. Vendors for soil fixation are readily available. Additional treatability work may be required to optimize the reagent doses. Other than the in-situ solidification component, Alternative 4 is similar to Alternative 3 in terms of implementability. However, the solidification component could be easily used on Area 2 if significant metal contamination were found.

Alternative 5 is the most complex alternative to construct and, during implementation, to operate. However, despite anticipated frequent downtime due to mechanical complexity, incineration could reliably meet the cleanup goals. A mobile incinerator would have to be located and brought onsite. During operation of the incinerator, this alternative would require the most attention because incinerators require periodic sampling of the residue and modification of operating parameters. However, the incinerator would operate for slightly more than a year, whereas the soil vapor extraction system of Alternative 4 would operate for 3 to 5 years.

As with Alternatives 3 and 4, some initial treatability work would be necessary to determine operating parameters. Other than locating, constructing, and operating the incinerator, the other implementability aspects of this alternative are similar to Alternatives 3 and 4. Incineration would also not be effective in treating Area 2 soils if metals are determined to be a health risk. The ash would be a hazardous waste under this scenario and would require disposal at an RCRA Subtitle C landfill.

Cost

Alternative 2 has a lower present worth and O&M cost than Alternative 3, but because of the additional cap required, it has a higher capital cost ($4,200,000 versus $3,300,000). The cap is one of the most expensive components to construct. Alternative 4 has a higher capital, O&M, and present worth cost than Alternatives 2 and 3. Alternative 5 has the highest capital ($13,000,000), first year O&M ($1,200,000), and present worth cost ($16,000,000) of all of the alternatives because of the incinerator component. The cost details of all of the alternatives are included in the appendix to this FS report.

State Acceptance

To be addressed in the ROD.

Community Acceptance

To be addressed in the ROD.

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